DICTIONARY OF ASTRONOMY AND ASTRONAUTICS

Dictionary of ASTRONOMY and ASTRONAUTICS

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PHILOSOPHICAL LIBRARY NEW YORK

PREFACE

This preface is being written on the eve of a lunar probe launching at Cape Canaveral. If the launching is successful it may set off a chain reaction producing new words or facts which might well have had their place in this book if its publicaton were a little longer delayed. If the launching is unsuccessful the new words and concepts will be only slightly delayed.

When this book was first planned many years ago radio astronomy was as yet unknown; the atom was still well named, because it had not yet been "broken"; space platforms and lunar probes and astronautics belonged primarily to science fiction; the scale of the universe was different; the perigee and apogee of orbits were not front page headlines.

Several times, during the lengthy years of work on this compilation it has been necessary to start all over again to study and abstract some new family of ideas and facts which had only recently demanded inclusion. If at any moment the book had ever been complete, it would not have remained that way for long. This is the nature of astronomical, astrophysical and astronautical advance.

From the beginning the goal has been to produce a hitherto unavailable reference book. This volume will supplant no text books, but it may offer answers in ready form for many who do not have a complete technical library at their fingertips.

The initial task is done. I wish that my long-time friend and associate at The Franklin Institute, Dr. William L. Fisher, might have lived to see it. It was his deep belief in the need for this book that persuaded me to agree to tackle it. My warm thanks

go also to my colleague, Albert A. Faulkner, who prodded and encouraged and lent active support when the task of keeping up to date appeared too formidable.

Without William A. Shawcross, of the editorial staff of SKY AND TELESCOPE, this volume might not yet be in publishable form. He has done a magnificent and deeply appreciated job of checking and editing, and although his work has been concentrated into the past year, he too has experienced the necessity of including brand new data which, briefly at least, will help us keep up to date.

My appreciation is directed too, to Dr. Dagobert D. Runes and Rose Morse of Philosophical Library, who did not lose patience with me although they might well have done so. All of us who have worked to produce this volume will welcome comments and suggestions.

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Yorklyn, Delaware
November 1918

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A

aberration of light

The apparent displacement of a celestial body in the direction in which the earth is moving, owing to the revolution of the earth around the sun. The apparent shift in the position of the body viewed is very small, since the velocity of light is enormous in comparison with the motion of the earth. (*see* ANGLE OF ABERRATION, ANNUAL ABERRATION, CHROMATIC ABERRATION, CONSTANT OF ABERRATION, DAILY ABERRATION, PLANETARY ABERRATION, SPHERICAL ABERRATION.)

abnormal stars

see PECULIAR STAR.

absolute altitude

see ALTITUDE.

absolute luminosity

The brightness that a given star would appear to have if it were the same distance from us as the sun, i.e., 1 astronomical unit, or 93,000,000 miles. (*see* LUMINOSITY.)

absolute magnitude

The magnitude of a star as it would appear if viewed from a distance of 10 parsecs (32.6 light years), where its parallax would be 0.1 of one second. On the other hand, the APPARENT MAGNITUDE of a star is its brightness as we see it. It depends upon its real brightness and on its distance. In order to rank the stars by their real brightness, it is useful to calculate how

bright they would be if they were all at the same distance. By agreement the standard distance is ten parsecs, or 32.58 light years.

Formula: If M is the absolute magnitude of a star, m its apparent magnitude and p its parallax, the absolute magnitude can be found by the formula $M = m + 5 + 5 \log p$.

There is a definite relation between the absolute magnitude of stars and their spectral classes. The B and A class stars have much greater absolute magnitudes than the K and M stars.

Giant and dwarf stars are so classed by their absolute magnitudes, and not by their diameters or their volumes.

The absolute magnitude of Cepheid variables bears such a definite relation to their periods that when the period is observed both the luminosity and the distance can be calculated.

By comparing the strength of the lines in the spectrum of a star with those of certain known stars, it is possible to estimate their absolute magnitudes. Then from the formula given above, their parallaxes and therefore their distances can be computed.

In general the larger, hotter, bluer stars have greater absolute magnitudes than the smaller, cooler, redder ones. So the determination of absolute magnitude helps to estimate these other characteristics.

(*see also* MAGNITUDE, MEDIAN MAGNITUDE OF A VARIABLE STAR, POGSON'S RATIO, STAR CATALOG.)

absolute temperature

Purely arbitrary scale devised by Lord Kelvin to eliminate the use of zero, plus and minus from thermometer scales when measuring gas volumes. 0° Centigrade is 273° K. The boiling point of water under standard conditions is 373° K. The lowest point is that at which a gas will theoretically have its volume reduced to zero, and there would be absolutely no heat. This point is practically unattainable. Also called K TEMPERATURE or KELVIN SCALE or KELVIN TEMPERATURE. (Cf. ABSOLUTE ZERO.)

absolute zero

The temperature at which all molecular motion ceases, i.e., 273 degrees below 0° Centigrade; it is the lowest temperature that it is theoretically possible to obtain. The degrees counted from this point are called degrees of ABSOLUTE TEMPERATURE (q.v.).

absorber

(1) in general, a substance that effects absorption (q.v.). – (2) A sheet or plate, etc., of some material or substance placed between a source of radiation and a detector in order to reduce the intensity of the radiation (*see* SHIELDING), to give the radiation some desired characteristics, or to help determine the nature or intensity of the radiation. – (3) In nuclear engineering, a substance that absorbs neutrons without reproducing them.

absorption

The process whereby radiation is stopped and reduced in intensity as it passes through matter.

absorption lines

The same as dark lines in the solar and star spectra (*see* ABSORPTION SPECTRUM).

absorption spectrum

The dark lines or bands produced in a continuous spectrum by the absorption of certain wave lengths of light.

Synonymous with DARK-LINE or REVERSAL SPECTRUM.

The spectra of the sun and most of the stars are absorption spectra, the absorbing material being cooler layers of gas in their atmospheres.

absorption of starlight

It has been found, in recent years, that space between the stars is not entirely transparent. The light of distant stars is dimmer and redder than it should be. Also there are some lines in their spectra that do not belong to the stars. These are now called INTERSTELLAR LINES

The belief is that there are huge clouds of very thin gas, calcium, sodium, potassium and titanium, that may average only a single atom in a cubic yard, but so large that they affect the light of distant stars.

These clouds are most numerous near the Milky Way, and in many patches they are dense enough to be called dark nebulae (*see* DARK NEBULAE).

acceleration

The rate of the increase in velocity of a moving body. In astronomy, it is frequently applied to the increase (true or apparent) of the orbital velocity of a celestial body that results in shortening of its orbital period. Thus, the *acceleration of the moon* is the increase of the velocity of the moon in its orbit, resulting in a shortening of its orbital period by 20 seconds a century. The *acceleration of the planets* is the increase in their speed as they proceed from aphelion to perihelion. The *acceleration of the stars* is the length of time by which their apparent daily motion exceeds that of the sun, i.e., 3 minutes 56 seconds a day. (*see* SECULAR ACCELERATION, also NEGATIVE ACCELERATION.)

acceleration of gravity

The rate of the increase in the speed of a body in free fall. On the Earth it is 981 cm. (about 32 feet) per second per second, i.e., a freely falling body increases the velocity of its fall by 32 feet per second in every second while it is falling. This acceleration is usually indicated by the symbol g. It is slightly greater (about 1/190) at the poles than at the equator, owing to the flattening of the earth.

accelerometer

(ASTRONAUTICS) An instrument for measuring ACCELERATION (q.v.).

accidental doubles

see DOUBLE STARS.

accidental errors

In all observations and measurements small errors are unavoidable. So some allowance for error must be made.

For instance in determining the parallax of a star, several observations are made and averaged It is found that the probable error is about .005″. If the star is very distant, and the parallax angle is very small, the percentage of error becomes very important. It may be greater than the angle measured.

Achernar

The traditional name of the star α Eridani (*see* STARS—*Plate X*).

achondrite

A type of the stony meteorites known as AEROLITES, characterized by the absence of CHONDRULES (q.v.)

achromat

see ACHROMATIC LENS.

achromatic lens

A lens that has been substantially corrected for chromatic aberration (q.v.), usually by combining two glasses having different dispersive powers, as, for instance, a convex crown-glass lens with a concave one of flint glass, or by enclosing a flint negative between two crown positives. Since the crown and the flint glass have different indices of refraction, the chemical and visual foci of the resulting combined lens coincide, and the image produced by it is relatively free from color. For certain purposes, three or more lenses may be combined in order to minimize the residual color.

acronical rising or setting

When a star rises when the sun sets and sets when the sun rises.

The opposite of COSMICAL RISING OR SETTING (q.v.)

actinometry

The science and technique of measuring radiant energy, particularly that of the sun, in its thermal, chemical and luminous aspects.

active prominence

see PROMINENCES ON THE SUN.

active-region prominence

A synonym for ACTIVE PROMINENCE.

acute exposure

With respect to radiation, short-term irradiation as contrasted with chronic or long-term exposure.

adiabatic

Occurring without loss or gain of heat.

aerial

A conductor or system of conductors designed for receiving or radiating radio waves. In RADIO TELESCOPES (q.v.) the purpose of the aerial is to select radio waves arriving from a specific direction and to transmit power extracted from such waves to the RECEIVER. The sources studied in radio astronomy are frequently very faint, so that aerials of high sensitivity and directional discriminating capacity must be used. A wide variety of models and ARRAYS (q.v.) of aerials are used, depending on the particular application. (Some of the types in common use are: the PARABOLIC REFLECTOR, the RHOMBIC and the YAGI AERIALS—q.v.).

Aerobee

A high-altitude research rocket which has been used, among other purposes, to carry mice and monkeys to high atmospheric altitude to test the effects of astronautical travel on living animal organisms. It has an overall length of almost 19 feet, a body diameter of 15 inches, weighs 300 lbs. when empty, and can carry a payload of not more than 200 lbs. It is launched from a launching tower by a solid-propellant

booster 6½ feet in length; it can reach an altitude of about 65 miles with peak payload, but has soared to as high as 100 miles with reduced payloads. An advanced model, the *Aerobee-Hi* is almost 21 feet long and can reach an altitude of 125 miles with peak payloads (200 lbs.) and nearly 200 miles with reduced payloads.

aerodynamic drag

The action of the air resistance that slows down a body moving through air.

aerodynamic vehicle

(ASTRONAUTICS)An unmanned vehicle designed for operation within the atmosphere, equipped with wings and control surfaces; essentially, it is a pilotless aircraft.

aerolite

A stony meteorite (q.v.) containing less iron and nickel than siderites and siderolites, and more silicon and magnesium oxides. The small proportion of metal is in tiny masses of nickel-iron alloy scattered throughout the stony mass. Many other terrestrial elements found. Aerolites largely made up of chondrules of the various material irregularly mixed, sometimes singly, sometimes in groups, giving evidence of having been subjected to fracturing forces. Aerolites are divided into two classes: ACHONDRITES (homogeneous, at times containing also nickel-iron particles; further divided into 11 subclasses) and CHONDRITES (consisting of rounded grains in a groundmass, often with nickel-iron particles; further divided into 5 subclasses).

aeropause

An upper region of the atmosphere in which the atmosphere ceases to function for manned or unmanned flight.

aerospace

Of or pertaining to the earth's envelope of atmosphere and the space above it, the two considered as a single realm

for activity in the launching, guidance, and control of ballistic missiles, earth satellites, space vehicles, and the like.

aether

see ETHER.

age of the earth

Geologists and physicists have, in the past few years, developed several ways of estimating the ages of various rocks, from the amounts of uranium, lead and helium contained in them. They conclude that the oldest known rocks are about 1½ to 2 billion years old.

Therefore the earth has been of about its present size and composition for at least that long.

If we look back to the formation of the solar system and the beginning of the earth it would be very much longer, possibly 8 billion years.

The estimates are not too accurate and so we usually say that the earth is somewhat more than two thousand million years old.

age of the universe

E. P. Hubble and M. L. Humason calculated, on the basis of the distances between galaxies and the velocity of their observed recession (q.v.), the age of the universe to be 1.8 billion years. According to W. Baade, however, the observed distances between the galaxies and the age of the universe calculated on the basis of the RED SHIFT (q.v.) must be multiplied by a factor of 2.8; this brings the age of the universe to approximately 5 billion years, which agrees with the age determined by calculations based on the radioactive decay of terrestrial substances and on the nuclear "fuel" consumption of the stars.

agonic line

Line at any point on which a magnetic compass has zero variation or declination, and therefore points both to magnetic

and true north. Because of the drift of the magnetic pole the agonic line varies slightly from year to year (*see* TERRESTRIAL MAGNETISM).

air

We live, and work, at the bottom of an ocean of air. All the light that comes to us from sun and stars passes through the air. Light is changed in direction and color by reflection, refraction and absorption in the air. Allowance for these changes must be made in many of our observations and measurements of the celestial bodies. (Cf. ATMOSPHERE.)

air break-up

(ASTRONAUTICS) The process of causing a guided missile or unmanned rocket, by means of a pre-set device or by a radio signal, to break into separate sections while descending toward the surface of the earth. This technique is applied to high-altitude research rockets that carry scientific instruments, to reduce the severity of the impact of the section housing the instruments as it hits the ground.

airglow

A faint glow in the sky above the earth; although its strongest radiations lie outside the visible band of the spectrum, and therefore not visible to human eyes, they are clearly detectable by sensitive instruments. This glow is present both by day and at night, and like the AURORA (q.v.) is caused by ionization of the minute particles of the atmosphere, although the glow present by day (*dayglow*) and that present at night (*nightglow*) appear to be the products of slightly different processes. There is also a *twilight glow,* which is a result of the direct effect of the sunlight on the atoms of the upper atmospheric layers; it is almost 100 times as intense as the nightglow, and yet cannot be detected visually because the sky is so much brighter by day than at night. (The formerly current designation, "permanent aurora," has been discarded in favor of the term, *airglow.*)

airlock

(ASTRONAUTICS) A small chamber equipped with an airtight door that gives access to an air-filled enclosure, and another airtight door to a part or full vacuum or airless space, to permit the transfer of objects or living beings from one to the other without escape of the air in the former.

Aitken's criterion for double stars

It is sometimes difficult to decide whether a star that appears double is a true binary, physically connected, or only a visual double, two independent stars that happen to be in the same direction.

The only absolute proof that two stars form a binary, or double, star is from observation of their motions. This requires many years.

Prof. R. G. Aitken, at the Lick Observatory, adopted a formula saying, the limit p'', for any magnitude, m, is log $p'' = 2.5 - 0.2m$. Thus the limiting separation is 200″ for the first magnitude, 20″ for the sixth, and 3″ for the tenth.

albedo

The percentage of light reflected from a surface; thus the ratio of the light reflected to that received from the sun on its whole illuminated surface.

The albedo of the moon is .07. That is, the moon reflects only 7% of the sunlight that it receives. The other 93% is absorbed and heats the surface.

The albedo of the planets given by C. W. Allen is:

Mercury .06	Saturn .42
Venus .61	Uranus .45
Earth .34	Neptune .52
Mars .15	Pluto .16
Jupiter .41	

Alcor

The traditional name of the star 80 Ursae Majoris, the close companion of Mizar.

Aldebaran

The traditional name of the star α Tauri (*see* STARS—*Plate X*).

Algol

β Persei, the "Demon Star," the oldest and best known of the ECLIPSING BINARY STARS (q.v.).

The Arabs named it the Demon Star, because it was in the constellation of al-Ghul (a demon). But not until 1783 was the reason for its varying brightness discovered by Goodricke, an English astronomer.

Algol is a second magnitude star, as bright as Polaris for most of the time. Every 2 d. 20 hrs. 49 min. its light decreases by two thirds and it becomes 4th magnitude for a few hours, then brightens again.

Algol is an ECLIPSING VARIABLE (q.v.), consisting of a bright star about 840,000 miles in diameter, very little smaller than the sun, and a larger but very faint star, about 1,060,000 miles in diameter; they revolve about a common center of gravity separated by approximately 3,250,000 miles. When the faint star passes between the earth and the bright star, it causes a partial eclipse that lasts for about 8 hours.

The two stars are scarcely denser than cork, about one fifth the density of the sun. They are so close together that because of their mutual attraction they are elliptical and not spherical.

The side of the faint star that is always turned toward the bright star is much brighter than its other side, probably because it reflects light from its brighter companion. (*see* ECLIPSING VARIABLES.)

Algol-type variables (Algol-stars)

see DARK ECLIPSING VARIABLES, ECLIPSING VARIABLES.

Alioth

The traditional name of the star ε Ursae Majoris; one of the stars in the Big Dipper.

all-burnt

(ASTRONAUTICS) A rather misleading term preferred in England for BRENNSCHLUSS (q.v.).

allburnt velocity

(ROCKETRY) The velocity that the rocket has acquired by the time the action of its motor ended.

Almagest

The Arabic name for a Greek book written by Ptolemy who lived in Alexandria about 150 A.D. It contains a catalog of 1080 stars, copied but corrected from Hipparchus of 150 B.C., and what is called the PTOLEMAIC SYSTEM of the structure of the solar system.

He believed that the earth was immovable and the center about which the sun, moon, planets and stars revolved.

For over 1400 years this book was the "Scripture of Astronomy," and its system the only one believed and taught.

almanac

A book or table containing a calendar of days, months and years, to which astronomical data and various statistics are often added, such as time of rising and setting of the sun and moon, changes of the moon, eclipses, hours of high and low tide, etc.

The most important one in America is the AMERICAN EPHEMERIS AND NAUTICAL ALMANAC.

almucantar

(1) An obsolescent term for a SMALL CIRCLE (q.v.) on the celestial sphere that is parallel to the horizon; today generally called a PARALLEL OF ALTITUDE or CIRCLE OF EQUAL ALTITUDE.
(2) An instrument for measuring altitude and azimuth.

Alpha Centauri

The nearest star beyond our sun, 270,000 times as far away. From it the Earth's orbit would appear to have a radius smaller than the diameter of a human hair as seen 45 feet

away from the eye. Thus the PARALLAX (q.v.) of this star is an angle less than the apparent motion of a strand of hair if moved through twice its diameter.

alpha decay, alpha disintegration

The radioactive transformation of a nuclide by the emission of alpha particles.

alpha emitter

A radioactive substance (q.v.) which gives off alpha particles (q.v.).

alpha particle

The positively charged nucleus of a helium atom, consisting of two protons and two neutrons; its weight is 6.6447 x 10^{-24} gram. Alpha particles (also called *alpha rays*) are emitted by radium and other heavy elements, and are readily absorbed by a few sheets of paper.

alpha radiation, alpha ray

see ALPHA PARTICLE.

alphatron

An ionization gauge that employs alpha particles emitted from a radioactive source,—a practical pressure gauge.

Alpheratz

The traditional name of the star α Andromedae (*see* STARS—*Plate X*).

Altair

The traditional name of the star α Aquilae (*see* STARS—*Plate X*).

altazimuth

The earliest type of mounting devised for astronomical telescopes: the telescope can be rotated both in altitude (i.e., about a horizontal axis) and in azimuth (i.e., about a vertical axis), and can be used to determine the altitude and azimuth of a celestial object. (The modern surveyor's transit or theodolite is a development of the altazimuth.)

altimeter

An instrument to determine altitude above the surface or *sea level.*

altitude

The angular distance of a celestial object from the horizon measured on its vertical circle from 0° to 90°. (*see also* APPROXIMATE ALTITUDE, COMPUTED ALTITUDE, MERIDIAN ALTITUDE, OBSERVED ALTITUDE, PRECOMPUTED ALTITUDE, SEXTANT ALTITUDE, TABULATED ALTITUDE.)

altitude circle

A circle parallel to the horizon, joining all points of equal altitude.

altitude difference

The difference between the COMPUTED ALTITUDE and OBSERVED ALTITUDE or between the PRECOMPUTED ALTITUDE and SEXTANT ALTITUDE (q v.) of a celestial body. The difference is designated as *T* (for "toward") when the observed altitude (respectively the precomputed altitude) is greater than the computed altitude (respectively the sextant altitude), otherwise as *A* (for "away"). Also called *altitude intercept.*

altitude intercept

see ALTITUDE DIFFERENCE.

aluminum-coated mirror

The best mirrors for reflecting telescopes are surfaced by the deposition of aluminum evaporated in a vacuum chamber. The film is about the thickness of a wave length of light. Its reflection efficiency is between 80% and 90% (Metal mirrors are about 60%.)These mirrors are very durable and will last for years when properly protected. Silver coatings must be renewed about every six months because of oxidation

Reflecting diffraction gratings for the spectroscope are also ruled on an aluminum surface. Sometimes the lines are ruled on soft glass which is then aluminized.

ammonia in planetary atmospheres

Research with the spectroscope has shown that the atmosphere of Jupiter is largely composed of ammonia and methane. The clouds of the belts are probably frozen ammonia crystals suspended in the atmosphere.

There is some ammonia in the atmosphere of Saturn, but the lower temperature there makes it probable that most of the ammonia has been frozen out of the atmosphere.

The same is true of the outer planets Uranus and Neptune.

amplitude

The distance measured in degrees along the horizon, from the east or west point, to the place where a vertical circle through the star, or other object intersects the horizon. It is the complement of the azimuth. The amplitude is given the prefix E or W. to indicate whether the body is rising or setting, and the suffix S. or N., depending on the direction of the body from the prime vertical; the prefix agrees with the meridian angle, and the suffix with the declination (q.v.).

anagalactic nebula

A synonym for EXTRAGALACTIC NEBULA (q.v.).

analemma

A graduated scale of the sun's declination and of the equation of time for each day of the year, drawn across the torrid zone on a terrestrial globe.

It has the form of a figure eight with one loop much larger than the other.

Andromeda [the Chained Lady]

Just south of Cassiopeia is the long constellation sometimes called the Princess.

It represents the daughter of Cassiopeia and Cepheus, who was chained to a rock on the seashore, to be eaten by the sea monster Cetus, because her mother bragged of her beauty. She was rescued by Perseus the hero.

Three second magnitude stars, evenly spaced in a nearly

straight line, mark the head, breast and hip. Above the middle star, a faint, hazy patch marks the great nebula, the most distant thing that can be seen by the naked eye. (*see* ANDROMEDA NEBULA.)

Andromeda "Nebula"

The brightest, and one of the nearest, of the spiral galaxies; the only one that can be seen without a telescope. It is a little above the bright star *Mirach* in Andromeda.

It is really a triple galaxy, having two smaller ones physically associated with it. It is about 1,500,000 light-years away from the earth. The main spiral has a diameter of about 140,000 light-years, and probably contains many billions of stars.

These measurements make it about the same size as our galaxy. Like ours it seems to be surrounded by many globular clusters, and it shows bright star-clouds and large dark areas similar to the dark clouds in our Milky Way.

This is the farthest object that can be seen with the naked eye, more than eight million trillion miles distant.

Andromedids

A meteor shower, the RADIANT (q.v.) of which is in the vicinity of γ Andromedae; the meteors of this shower are slow moving. Visible in the second half of November, reaching its maximum about November 27. Associated with Biela's comet, hence also referred to as BIELIDS.

angle of aberration

The angle by which a telescope must be tilted to compensate for the ABERRATION OF LIGHT (q.v.). Since the velocity of light is roughly 10,000 times the velocity of the motion of the earth, this angle is very small. (*see* CONSTANT OF ABERRATION.)

angle of conversion

see CONVERSION ANGLE.

Angstrom

A unit for measuring the wave lengths of light.

One angstrom is a hundred-millionth of a centimeter, or 4 thousand-millionths of an inch.

It is abbreviated as A (or Å) or by the Greek letter lambda (λ).

The visible spectrum lies between λ3900 and λ8000. It has been photographed as far as λ2900 in the ultra-violet, and λ13,500 in the infrared.

angular diameter

The angle subtended by the diameter of a circle at the eye of the observer.

angular distance

The angle subtended at the observer's eye. (*see* DISTANCE BETWEEN STARS.)

angular momentum

The product of the moment of inertia of a rotating body or system, as measured about any axis of rotation, by the angular velocity about the same axis. It equals the product of the mass and the area swept over by the radius vector in unit time. Its value is one-half of the value of the MOMENT OF MOMENTUM (q.v.). (*see also* CONSERVATION OF ANGULAR MOMENTUM.)

angular motion

The motion of a body about a fixed axis, measured by changes in its angular direction from a fixed line.

angular velocity

The rate of change in angular displacement, i.e., in direction, of a point in motion with reference to a point not in motion per unit of time. It is usually expressed in radians per second.

annihilation of matter

New concepts in physics have brought changes in belief in the theory of the conservation of matter.

Einstein's famous equation $E = mc^2$, where E is energy, m means mass and c the velocity of light, means that matter

can be transformed into energy. (*see "How the sun shines"* under SUN.)

It is believed that, in the sun and the stars, with their very high temperatures, atoms are split into protons, neutrons and electrons, which combine into other atoms, with some loss of mass and production of large amounts of energy.

annual aberration

The apparent displacement of a star in the course of a year owing to the revolution of the earth about the sun, the ABERRATION OF LIGHT (q.v.) causes the star to appear to trace a very small circle in the sky every year.

annual equation

This is a perturbation, or irregularity, in the motion of the moon.

During the half of the year where the earth is nearer the sun than the average distance, that is in our northern winter, the pull of the sun on the moon is greater and the month is lengthened a little, and the moon keeps falling behind its average position. During the other half of the year it catches up again.

The maximum inequality is 11 minutes 9 seconds in the period of one anomalistic year.

annual parallax

see PARALLAX.

annular eclipse (ring eclipse)

Because the orbits of the earth and of the moon are ellipses the distance between them varies from 221,463 miles to 252,-710 miles. If an eclipse of the sun occurs when the earth is nearest to the sun, and the moon is farthest from the earth, the moon's shadow is not long enough to reach the earth by 20,500 miles. Therefore the moon does not entirely cover the sun and leaves a ring (or annulus) of the sun's disk around the darkened moon.

Annular eclipses are 20% more frequent than total eclipses. An annular eclipse would be total if the moon were closer to the earth, or the sun farther away, resulting in an exact equality of the apparent diameters of the two bodies. An eclipse that begins and ends as an annular one, but is a total one over a part of its path, is called a *total-annular eclipse*.

anomalistic month

The time required for one revolution of the moon, perigee to perigee. Its length is 27.5546 days.

anomalistic year

Period of one complete revolution of the earth around the sun relative to two successive perihelion passages. This is different from the sidereal year because perturbations from other planets cause the perihelion point to advance slightly. Its length is 365.2596 mean solar days, or 365 days, 6 hours, 13 minutes, 53 seconds.

anomaly

Originally, any periodic inequality in the orbital motion of a planet; today, unless otherwise specified (*see* ASTRONOMICAL ANOMALY, MEAN ANOMALY), the term is used to refer to the TRUE ANOMALY (q.v.) of the orbit.

anoxia

Absence of oxygen in the body.

ansae of Saturn

The extremities of the rings as they look like handles to the planet.

antapex

The point on the celestial sphere opposite to the APEX OF THE SUN'S WAY (q.v.). In Columba, about 30° S of Orion's belt.

The stars in this part of the sky all appear to be closing in toward a point, from which the solar system is retreating at about 12 miles per second.

Antarctic Circle

66½° south latitude. The parallel 23½° from the South Pole. South of this line the sun does not set for some days at the beginning of southern summer, near the end of December. (*see* MIDNIGHT SUN.)

Antares

The traditional name of the star α Scorpii (*see* STARS—*Plate* X).

antecedence

The apparent motions of a planet toward the west.

It happens to Mercury and Venus when they pass between the sun and the earth.

The superior planets appear to move westward every year when the earth passes them.

antenna

see AERIAL.

antigravity

Hypothetical effect of cancellation or reduction of gravity.

antimeridian

That part of the celestial meridian that lies below the horizon and includes the nadir.

Antlia [the Air Pump]

A southern constellation.

apastron

The time when, and the point at which, the two components of a binary star are the farthest apart as they revolve in their orbits. (Cf. PERIASTRON.)

aperiodic

Not occurring regularly, but taking place at unequal intervals of time.

aperture of a telescope

The clear diameter of the objective lens or mirror.

It is stated in inches when giving the size of the telescope. A 12 inch telescope has an aperture of 12 inches.

apex of the Sun's way

The point near the edge of the constellation Hercules, about 10° southwest of Vega, toward which the sun and the whole solar system are moving at the rate of 12.2 miles per second. The point diametrically opposite to it is the ANTAPEX.

aphelion

The point on the orbit of a planet or comet where it is farthest from the sun.

The earth is at aphelion about July 1. The exact date and time varies somewhat, and advances, on the average, twenty-five minutes a year. (Cf. PERIHELION.)

apocynthion

The position where and the time when a rocket or other object is farthest from the moon.

apogee

The point in the moon's orbit where it is farthest from the earth. Its distance is then 252 710 miles. Also recently adopted in connection with artificial earth satellites to specify their greatest distance from the earth.

Apollo

The name given by the Greeks to the planet Mercury when it was a morning star.

They called it Mercury in the evening.

apparent

As something appears or as we see it.

apparent diameter

Angular diameter (*see* DIAMETER).

apparent distance

With reference to two stars, this term means their difference in direction, measured in degrees, minutes or seconds of arc.

apparent magnitude

The brightness which a star or other heavenly body appears to have, in contradistinction to its real brightness which is referred to as the ABSOLUTE MAGNITUDE (q.v.).

apparent noon

The moment when the center of the sun is on the meridian.

apparent position

With reference to a star or other heavenly body, the position where it seems to be, measured by right ascension and declination. (Cf. CELESTIAL SPHERE.)

apparent rotation

The daily westward movement of the sun and the stars across the sky.

apparent size

The size that something appears to have. The sun and the moon appear in the sky to be of the same size.

apparent solar time

see TIME.

apparent time

see TIME.

Appleton layer

A layer of the IONOSPHERE above the HEAVISIDE LAYER (q.v.); it is ionized and reflects shorter wavelengths and higher frequencies than the radio waves of 3000 kilocycles. Also called *F layer*.

approximate altitude

An approximation of the angular distance of an object above the horizon, such as might be obtained from a star finder.

approximation

Continued approach nearer and nearer but never actually arriving. Some problems are solved by this method when an actual, exact solution is impossible.

apse

A synonym for APSIS (q.v.).

apse line

see LINE OF APSIDES

apsis (plural: apsides)

The designation of those points of the orbit of a celestial body where the body is at the greatest or the shortest distance from the center of attraction (*see* APHELION, APOGEE, LINE OF APSIDES, PERIGEE, PERIHELION.)

Apus [the Bird of Paradise]

A southern constellation.

Aquarids

The common designation of two meteor showers the RADIANT (q.v.) of which is in the constellation Aquarius. The η Aquarids possibly associated with Halley's comet, April 30-May 6, with 6-7 long very rapid meteors per hour at the maximum, and the δ Aquarids, July 20-August 25, with the maximum about July 30, consisting of typically long slow-moving meteors.

Aquarius [the Water Bearer]

A large but inconspicuous constellation, the 11th in the zodiac, south of Pegasus.

It represents a man pouring water from a jar, but there are almost no stories about it. Some of the Greeks said it was Zeus pouring rain on the earth.

A little group of 4 small stars forming a triangle with a star in the center is the water jar. A very irregular line of stars is the stream of water pouring into the mouth of the Southern Fish, at the bright, 1st magnitude star Fomalhaut.

There is also a figure of 8 stars suggesting South America, and 6 stars form a crude long-handled dipper.

Herschel discovered the planet Uranus in this constellation.

Aquila [the Eagle]

South of Cygnus, and across the Milky way from Vega, is the constellation Aquila.

It represents the black eagle into which Jupiter changed himself when he carried away Ganymede to become cup-bearer to the gods on Mount Oympus.

The stars form no figure of a bird. There are three stars in a row with the brightest one in the middle.

Altair, 1st magnitude, is the 12th brightest star in the sky. Its diameter is 1.6 that of the sun and it is 16 light years away. Eta Aquilae is a Cepheid variable with a period of 7 days

Ara [the Altar]

A southern constellation.

arc

A portion or segment of a curved line, such as a circle or ellipse, hence, the orbital distance separating two points or two bodies (*see* ELECTRIC ARC)

arc of progression

The arc that a planet in DIRECT MOTION (q v) describes in the sky.

arc of retrogression

The arc that a planet in RETROGRADE MOTION (q v) describes in the sky.

arc over

(ASTRONAUTICS) The change of direction of a guided missile or rocket after its powered ascent as it changes course to move into its predetermined trajectory or orbit (Also used as a verb, *to arc over.*)

arc spectrum

The spectrum obtained from an electric arc, showing the presence of chemicals

It is much hotter than a furnace spectrum, and some of the gases are ionized.

Arctic Circle

66½° north latitude.

The parallel 23½° from the North Pole. North of this line there are some days near the summer solstice when the sun does not set, but is above the horizon for the whole twenty-four hours. (*see* MIDNIGHT SUN.)

Arcturus

The traditional name of the star α Boötis (*see* STARS—*Plate X*).

area

Cf. LAW OF EQUAL AREAS.

areal velocity

see LAW OF EQUAL AREAS.

Areography

The study of the surface of Mars.

Argelander method

A method of estimating the difference in brightness of variable stars, developed by Argelander, an astronomer at Bonn. It consists in estimating the number of just perceptible steps between the variable stars and one or more stars supposed to be invariable. If the variable is denoted by v, and the comparison stars by a and b, the statements $a\ 3\ v\ 4\ b$ means that the variable is 3 steps fainter than a, and 4 steps brighter than b.

Argo [the ship Argo]

A large southern constellation, often referred to by its full Latin name, *Argo Navis*. It is subdivided into four groups: *Carina* [the *Keel*], *Puppis* [the *Poop*], *Vela* [the *Sail*], and *Pyxis Nautica* [the *Marine Compass*], usually referred to simply as *Pyxis*, which are regarded by many astronomers as a separate constellation. The star α Carinae (better known as *Canopus*) is outranked in brightness by Sirius alone. (*see* STARS—*Plate X*.)

Argument

A term used to indicate any number or quantity by which another is determined.

Ariel

A satellite of Uranus. (*see* SATELLITES OF THE SOLAR SYSTEM.)

Aries [the Ram]

The first constellation in the zodiac.

A small constellation in which only 3 stars are easily seen. Hamal is 2d magnitude, Sheraton 3d and Mesarhim 4th. They are in the head of the animal.

It represents the ram on which Phrixus and Helle rode through the air to escape from their stepmother Ino. Helle fell off and was drowned in the Hellespont. Phrixus rode on to Colchis, where he sacrificed the ram and hung its golden fleece on a tree from which it was captured by Jason of the Argonauts.

A few thousand years ago the vernal equinox was in Aries. It is now in Pisces. But Aries is still the first sign.

armilla

The Chinese invented an instrument to mark the equinoxes. A flat ring was set in the ground in the plane of the equator. The sun shone on the south side of it during autumn and winter. On the first day of spring the light touched the north side, and shone there until the autumnal equinox.

This was brought to Greece, and Eratosthenes used one about 240 B.C. It went to Rome a little later. The circle was too large for a ring and so they called it a bracelet.

The Greeks and Romans added other circles for meridian, ecliptic, zones, etc. and it became an armillary sphere (*see* ARMILLARY SPHERE.)

armillary sphere

An ancient instrument consisting of a number of metal rings

representing the celestial equator, ecliptic, and the other circles of the celestial sphere.

array of aerials

A system of AERIALS (q.v.) coupled together in order to obtain directional effects; they may be arranged in the direction of the radiation (*end-on* or *alignment array*) or in a line perpendicular to that direction (*broadside array*).

artificial earth satellites

see NOMENCLATURE OF ARTIFICIAL SATELLITES, SPUTNIK.

artificial gravity

(ASTRONAUTICS) The effects of centrifugal force proposed to be utilized to simulate those of gravity in manned rockets and space stations beyond the effective gravitational field of the earth or another celestial body.

artificial horizon

A small shallow basin of mercury to reflect the sun when using a sextant on land.

From a ship at sea the height of the sun can be measured from the real horizon. On land this is seldom possible. The surface of mercury gives a true horizontal surface, and half the height of the sun above its reflected image gives the altitude.

artificial meteor

The designation given to the aluminum pellets (each ½ inch in diameter and weighing a few grams) more than 100 of which were launched from an airborne Aerobee research rocket in an astronautical experiment on October 16, 1957. The experiment, suggested by F. Zwicky, was based on similar operations executed with V-2 rockets in 1947, and was conducted by the Geophysics Research Directorate of the Air Force Cambridge (Mass.) Research Center. The Aerobee carried three SHAPED CHARGES (q.v.) in its nose cone, which exploded at the altitude of 55 miles and hurled the pellets forth at a velocity of 40,000 m.p.h. Many of the pellets were

believed to have escaped into outer space, to move about the sun in cometlike orbits or to be swallowed up by it.

artificial radioactivity

Radioactivity produced by bombardment of an element with nuclear particles.

artificial satellite

(ASTRONAUTICS) A rocket, space vehicle or other man-made object designed to be placed into an orbit of its own around the earth. The term embraces both manned and unmanned objects. (*see* SPUTNIK.)

ascending node

The intersection of the ECLIPTIC (q.v.) and the orbit of a heavenly body which that heavenly body passes on its way from the south to the north of the ecliptic. (Cf. NODES OF THE MOON'S ORBIT.)

ascension, right

see RIGHT ASCENSION.

ashen light

A phenomenon observed on the planet Venus: when Venus is in the crescent stage, its non-luminous portion is often seen as dimly shining, so that the full disk can be detected. The phenomenon is similar to the EARTHSHINE (q.v.) observed on the moon, but no explanation has been found for it as yet, since there is no known body sufficiently close to Venus to illuminate it by reflected light.

aspect indicator

(ASTRONAUTICS) An instrument designed for use in rockets and missiles to register and indicate the position of the axis of the rocket or missile with reference to its course.

aspects

All the different appearances of the moon, or of Venus and

Mercury, due to their differing distances east or west of the sun or elongation. Also called PHASES (q.v.).

Special aspects of the moon are called PHASES (q.v.).

association of stars

A term introduced by V. A. Abarzumian to denote certain very loose groupings of stars.

assumed position

Position used for the determination of computed altitude. It may be a dead reckoning or estimated position, or one assumed by another position nearby.

aster

Obsolete term for star.

asterion

Greek for "small star."

asterism

A group of stars. The word used to mean the same thing as constellation. It is now used for a smaller group of stars. The Pleiades are considered an asterism in the constellation of Taurus The Big and Little Dippers are also asterisms.

asteroids (planetoids, minor planets)

Many small bodies revolve about the sun, mostly between the orbits of Mars and Jupiter. Their periods are between 3½ and 6 years. Only one, Vesta, is visible to the naked eye. Over 1500 have been discovered A few are named. Most bear only catalog numbers.

Ceres, the largest, 188 miles in diameter, was the first one discovered, on Jan. 1, 1801.

Pallas, second largest, 304 miles, *Vesta* third 240 miles and *Juno* fourth, 118 miles were discovered by 1807.

Five asteroids come closer to the earth than any other planet.

Eros, 20 mi. in diameter comes within 14 million miles,

every 44 years. Next close approach in 1975. This body was used in finding the most accurate measure of the distance from earth to the sun.

Amor, discovered in 1932, comes within 10 million miles once in 11 years.

Apollo, only 1 mile in diameter, moves to 8 million miles, within the orbit of Venus. It passes the earth at two points less than 3 million miles away.

Adonis, 1 mile in diameter, passes the earth at about 1 million miles, passes Venus and Mars at about the same distance, and gets within 5 million miles of the orbit of Mercury.

Hermes, less than 1 mile in diameter, passes the earth at less than 1 million miles.

Asteroids are discovered by making long time exposures of photographic plates with the telescope set to follow the stars. Stars appear as points, asteroids trace short lines. Their orbits are more eccentric than those of the planets and are sometimes highly inclined to the plane of the ecliptic.

Some of the asteroids are grouped into families. Two of these, one of 4 and the other of 5 bodies, are called the Trojan or Jupiter asteroids. Their orbits are nearly the same as that of Jupiter and one group goes ahead of, and the other follows the giant planet around the sun.

The origin of the asteroids is not known. One theory is that they are fragments of a planet that was broken to bits. Another that they are small bodies that never got together to form one larger planet.

The mass of all combined would be only about 1/2000 the mass of the earth or 4/100 the mass of the moon.

astral

Relating to or characteristic of stars or a specific star.

astrionics

The art or science of adapting electronics to space flight.

astrobiology

A branch of biology concerned with the discovery or study of life on other planets.

astrogation

Space navigation.

astrography

That branch of astronomy which deals with the positions, composition and other characteristics of the stars.

astrolabe

An ancient instrument for measuring the altitudes of a star above the horizon (an *altimeter*), invented probably by Hipparchus, in Alexandria, about 240 B.C. under Almagest.

It consists of a graduated metal disc, with a ruler called the alidade, which has sights for observing a star and an edge for reading the lines on the disc. There is a handle from which it hangs so that it will always be vertical.

During the Dark Ages the astrolabe was forgotten in Europe. but the Arabs kept and improved it. It was brought back to Europe in the XIIIth century, and for the next four centuries no voyage of exploration was made without its help.

Columbus had one when he discovered America.

Between the 13th and 18th centuries astrolabes became very elaborate and complicated. Some were set on a base parallel to the ecliptic. Some had interchangeable plates for different latitudes.

With an astrolabe, and proper tables, one could tell time, direction, and several other things. Some were made especially for use in astrology.

They became obsolete with the invention of better instruments like the forestaff, backstaff, quadrant and sextant

astrolabe a prisme

An instrument with which very accurate simultaneous determinations of latitude and time may be made by observing

the times when a number of stars reach the same fixed altitude.

astrology

The pseudo-science which treats of the influences of the stars upon human affairs, and foretelling terrestrial events by their positions and aspects.

It was developed by the Chaldeans, Greeks and Egyptians. Much ea ly astronomical knowledge can be traced to astrology.

astrometer

An obsolescent name for a stellar PHOTOMETER (q.v.).

astrometric companion

An unseen companion of a visible star, revealed by variations observed in the proper motions of the latter.

astrometry

The branch of astronomy that deals with the measurements of the celestial bodies, especially those to determine their sizes, position and movements.

astronaut

A person actively engaged in ASTRONAUTICS (q.v.); one concerned with flying through space, or one who navigates through space.

astronautics

The science and technique of space flight. Defined by the Air Force Dictionary as "The art and science of flying through space or sending winged guided vehicles or missiles through space."

astronomical anomaly

The angular distance of a planet from its perihelion as seen from the sun.

astronomical calendar

A chart designed to show the phenomena of the planets, the moon and the sun throughout the year, and to indicate their positions in the sky for every day.

astronomical clock

A clock, in its original form pendulum driven, in its modern version electrically operated, that shows SIDEREAL TIME (q.v.), gaining about 4 minutes a day, i.e., 24 hours a year, in comparison with an ordinary clock.

astronomical day

see DAY.

astronomical latitude

The angle between the direction of gravity at a given place and the plane of the equator, it equals the altitude of the celestial pole.

astronomical refraction

The bending of a ray of light as it passes from the vacuum of space into the atmosphere, the deviation of the ray from its original direction increases the closer it gets to the surface of the earth.

astronomical symbols

see SYMBOLS.

astronomical telescope

The general designation of the class of telescope designed for astronomical observations, the principal varieties being the EQUATORIAL and the MERIDIAN CIRCLE (or TRANSIT CIRCLE) (q.v.).

astronomical time

The system of measuring, keeping and recording time used by astronomers in general It is the MEAN SOLAR (CIVIL) TIME, the day being counted from midnight to midnight.

astronomical triangle

A spherical triangle used for the solution of astronomical problems. Its vertices are the *zenith*, the *elevated pole*, and the *celestial body* observed, its three sides are the *co-latitude* (the complementary angle of the observer), the *polar distance* of the celestial body (the complementary angle of its declina-

tion), and the zenith distance of the celestial body (*the complementary angle of its altitude).*

astronomical twilight

The period before sunrise or after sunset during which the center of the sun is not more than 18° below the horizon. (see TWILIGHT.)

astronomical unit (A.U.)

A measure for distances within the solar system, equal to the mean distance of the earth from the sun, i.e., 93,000,000 miles.

astronomy

The "science of the stars," including with the stars the study of all the bodies in the universe. It is the oldest and most comprehensive of all the sciences.

Because its field is so large, it has been divided into various sections.

Observational astronomy deals with the instruments with which our knowledge of the celestial bodies is gained: telescopes, spectroscopes, cameras and their uses and the vast quantities of records made by the observers.

Practical astronomy deals with the knowledge gained by the observers for navigation (NAUTICAL ASTRONOMY—q.v.), surveying, the measurement of time, etc.

Geometrical astronomy defines and measures the positions and motions of the celestial bodies with regard to a fixed system of points, lines and planes. The points chosen are the observer's position on the earth, the center of the earth and the center of the sun. The basic lines are the coordinates of the positions of the bodies to be studied. The fundamental plane is the plane of the ecliptic.

Descriptive astronomy deals with the enumeration and description of the celestial bodies, but without regard to physical and mathemaucal theories.

Mathematical astronomy is that branch of applied mathe-

matics which derives the laws of motion of the celestial bodies, from their gravitation toward each other, or from the mutual action of the parts which form them. (*Also called* CELESTIAL MECHANICS and GRAVITATIONAL ASTRONOMY.)

Interpretive astronomy. The opening of planetariums in recent years has created a new section of astronomy and a number of persons whose business it is to interpret the work of other astronomers to people who are not scientifically trained. They have produced a number of books that are scientifically accurate, but written in words that are easily understood. They have learned to make astronomy both interesting and attractive to the general public and to children.

Radio astronomy is the youngest branch, it deals with the study of the electromagnetic impulses emitted by celestial bodies and regions ("RADIO SOURCES"—q.v.) and with the study of the universe as revealed by the radio waves instead of the visible light frequencies of the electromagnetic spectrum. (*see also* ASTROPHYSICS.)

astrophysics

That branch of ASTRONOMY (q.v.) which deals with the material constitution, chemical composition, temperature etc. of the stars and other celestial bodies through the application of the laws and principles of physics, it may thus be regarded as a combination of astronomy and physics.

asymmetry

Want of symmetry or proportion

ataxites

A type of the all-metal ("iron") meteorites known as SIDERITES (q.v.), they are essentially structureless masses of metal.

Atlas

An intercontinental ballistic missile of the U. S Air Force, equipped with a nuclear warhead. After a successful test firing, the following details were announced on December 17, 1957: Range, 5000 miles, powered by a liquid-propellant (liq-

uid oxygen and hydrocarbon) rocket motor which delivers about 135,000 lbs. of thrust, and equipped with two boosters with almost 100,000 lbs. of thrust each.

atmosphere

The gaseous envelope of a celestial body.

atmosphere of the earth

The gaseous envelope that surrounds the earth consists of the mixture that we call air. It is an invisible, odorless, tasteless mixture of a number of gases. It is not a chemical compound. It contains: nitrogen 78.03%, oxygen 20.99%, argon .9323, carbon dioxide .03, hydrogen .01, neon .0018, krypton .0001, helium .0005, ozone .00006, xenon .000009. Besides these gases it contains a little water vapor, about 1.2%, and varying amounts of dust and smoke.

The atmosphere is usually divided into several layers. The lowest one is called the TROPOSPHERE which extends upward to about seven miles. It is the region of winds and clouds. All our weather is in this layer. In it the temperature drops about 18.5°F, for every mile that we ascend, from an average of 20°F at the surface of the earth to –67° at the top of the troposphere. Because the density of the air decreases rapidly with the elevation, this thin layer of the troposphere contains 80% of the mass of the entire atmosphere. The next layer (the boundary of separation which from the troposphere is called the *tropopause*) is the *stratosphere* which extends up to about 60 miles from sea level. It is too thin to support life, and since it contains hardly any water vapor, there are no clouds in it either. Above the stratosphere lies the *ionosphere*, in which the atoms are partly ionized. It can be divided into several layers designated by Roman capital letters, the most important divisions being the *Heaviside-layer* (also called *Heaviside-Kennelly layer* or *E layer*) which deflects radio waves up to a frequency of 3000 kilocycles, and the *Appleton layer* (also called *F layer*) which deflects shorter waves.

Above the ionosphere, at an altitude of about 500 miles above sea level lies the outermost stratum of the atmosphere, called the *exosphere*, where the air is no longer a continuous medium, but a mass of molecules that move around the earth in independent orbits; the exosphere blends into the near vacuum of outer space. This vast body of air weighs about 6,000,000,000,000,000 tons, and the pressure that it exerts on the earth is 14.7 pounds per square inch, or a ton per square foot.

All the light that comes from the sun and stars, must pass through this air. It absorbs some of the light, refracts it, so that stars are not always where they appear to be, causes the stars to twinkle, produces the northern lights, and makes the meteors visible. It has other effects that are likewise very important. It fends off the extreme ultra-violet radiation from the sun, that is destructive to life. It scatters the short wave lengths of the light and so gives us the blue of the sky, and the brightness that makes the stars invisible in the daytime. It transmits the longer waves of yellow, orange and red light, and especially the still longer heat rays, thus permitting the sun to warm the earth. It acts like a blanket to prevent the rapid radiation of heat from the earth so that we do not freeze every night as we would if the earth, like the moon, had no atmosphere.

For the atmospheres of the other planets, the sun and the stars see the entry on each such body.

atmospheric braking

The planned use of atmospheric drag to slow down a vehicle to prevent overheating

atmospheric drag

(ASTRONAUTICS) The retarding effect of air resistance that slows down a body moving through the atmosphere.

atmospheric pressure

The force per unit area exerted by the atmosphere in any part of the atmospheric envelope.

atmospheric tides

Small fluctuations in the atmosphere owing to the gravitational action of the sun and the moon, analogous to the generation of tides of the seas.

atmospheric windows

The atmospheric envelope of the earth absorbs practically every frequency of the electromagnetic spectrum, except for those of visible light and shorter radio waves. Those two bands of electromagnetic radiation, the only ones to which the atmosphere of the earth is transparent, may therefore be thought of as two "windows" in an otherwise opaque atmosphere, namely: the *"optical window,"* through which we can view the universe by naked eye and through optical telescopes, making use of the wavelength and frequencies of visible light, and the *"radio window,"* through which the radio telescopes can scan the universe and furnish us with new data, "seeing" by the short radio waves.

atmospherics

Electrical disturbances originating in the atmosphere by electrical discharges, or in some local piece of electric apparatus, and manifesting themselves as grinding or crashing noises in radio receiving sets. (Also called *static* or *strays.*)

atom

The smallest stable unit into which an element can be divided.

The ancient Greeks evolved a theory that all matter was made up of tiny particles that they called atoms. We still use that theory.

The chemists say that there are 102 kinds of atoms corresponding to the 102 chemical elements.

Until recently an atom was defined as the smallest particle of matter that could exist.

The physicists now say that an atom is made up of a number of still smaller particles. These are proton, neutron, elec-

tron, called fundamental particles; also there are the positron, meson, neutrino, and others.

According to our present view, an atom consists of a small, heavy nucleus, about 10^{-12} centimeter in diameter surrounded by a comparatively large, empty region 10^{-8} cm. in diameter, in which electrons resolve somewhat like planets around the sun.

The nucleus of the atom carries a positive charge of electricity, on the protons This is balanced by the negative charges on the equal number of electrons revolving about it.

If energy is added to the atom, its electrons are made to revolve in large orbits. If energy is emitted, they drop back into smaller orbits.

Atoms are said to exist in several states. NORMAL ATOMS are in the lowest energy state.

They can not emit light nor heat. When they absorb energy, one or more electrons are transferred to larger orbits, and they become EXCITED ATOMS capable of giving off light and giving characteristic lines in the spectrum.

Neutral Atoms are those that contain their full quota of electrons, as many as there are protons in the nucleus. In this condition the atoms are electrically neutral.

IONIZED ATOMS are those that have lost one or more of their electrons. By absorbing energy some electrons have been driven beyond the outermost orbit and have become free electrons.

Atoms may be singly, doubly or more highly ionized, as one, two or more electrons have been driven off.

It is now possible to transform atoms of one chemical element into those of another. This is sometimes called "splitting atoms." It is believed to take place in the sun and the stars, under the influence of their extremely high temperatures. (*see* CARBON CYCLE.)

It is also possible that atoms can be stripped of all their electrons, and so the nuclei packed very closely together. This

is an explanation of the enormous densities of some of the white dwarf stars. (*see* COMPANION OF SIRIUS.)

atomic energy

A popular term for NUCLEAR ENERGY (q.v.).

atomic number

An integer that expresses the positive charge of the nucleus of an atom of a given element in multiples of the electronic charge, *e*: it equals the number of protons in the nucleus and also the number of electrons revolving about the nucleus. Symbol: Z.

atomic waste

The radioactive ash produced by the splitting of uranium or other nuclear fuel in a nuclear reactor; it may include products made radioactive in such an apparatus.

atomic weight

The relative weight of an atom of an element referred to the exact value of 16.0000 for oxygen. In determining the *atomic weight on the chemical scale*, the average weight of the atoms of oxygen of isotope distribution found in fresh lake or rain water is taken as 16.0000, for the determination of the *atomic weight on the physical scale*, the atomic weight of the principal oxygen isotope (O^{16}) is given the exact value of 16.0000. The atomic weight of an element on the physical scale equals its atomic weight on the chemical scale multiplied by 1.000272. The symbol for atomic weight is: *A* or *awu*.

attenuation

In radiation theory, the reduction of flux density per unit area with the increase in the distance between source and target, or to scattering and/or absorption.

attitude

(ASTRONAUTICS) The position of a rocket, missile or artificial satellite, as determined by the inclination of its axis to some frame of reference.

attraction

A force acting mutually between particles, or bodies, of matter tending to draw them together and resisting their separation.

Gravitation is the supreme example.

A. U.

The abbreviation of ASTRONOMICAL UNIT (q v).

aureole

The clear area between a CORONA or HALO (q v) and the sun or the moon

Auriga [the Charioteer]

A constellation just east of Perseus, an irregular pentagon of five bright stars, one of which is 1st magnitude.

It represents the inventor of the chariot Auriga, a man born a cripple He has a horsewhip in one hand, but on his left arm he carries a goat and two little kids In very ancient times the figure represented a shepherd caring for his flock.

Capella the bright star is the sixth brightest in the sky. It is 16 times the diameter of the sun but radiates nearly 200 times as much light It is 47 light years away It is of the same color and spectral class as the sun

Capella is in the body of the she-goat, and three small stars near it, in a narrow triangle, are the kids

aurora (plural: aurorae)

A diffused glow, bright patches, streamers, arches or dancing color patterns that are frequently seen in high geographic altitude (approximately above 70) both north and south. The aurora seen in the northern hemisphere is referred to as *Aurora Borealis* or the *Northern Lights*, that in the southern hemisphere is known as *Aurora Australis* or the *Southern Lights* The generation of the aurorae has been explained as follows. Electrified particles stream out of sunspots and are attracted by the magnetism of the earth toward the geomag-

netic poles. As they enter the atmosphere, they produce an ionization in the attenuated gases of the upper atmospheric *layers, and make those gases glow, the same way as an electric discharge causes a glow in glass tubes that we call neon signs.*

The light of the aurora is usually a pale greenish white. Yellow and red colors are not uncommon. Blue and purple are rarely seen. Auroral light is diffused over the sky at all times. It is only when it is more brilliant that streamers and arches can be seen. Aurorae appear always high above the earth; their known height varies between a minimum of 30 miles and a maximum of 600 miles. According to a report of Prof. A. C. B. Lovell, it has been definitely established that aurorae occur in the Arctic and Antarctic simultaneously. They are more frequent when the sunspots are numerous. They are always accompanied by disturbances of the magnetic compass needle which at times are serious enough to interfere with radio and even with telegraphy and telephone service; in that case they are called *magnetic storms.*—The phenomenon formerly called "permanent aurora" is called today AIRGLOW (q.v.).

austral

Southern. Lying or being in the south.

Thus AURORA AUSTRALIS (q.v.) is the southern lights, and CORONA AUSTRALIS the southern crown.

autumnal equinox

The position on the ecliptic occupied by the sun about September 23, when it crosses the celestial equator going from north to south.

average life

In nuclear physics, the average of the individual lives of all the atoms of a given radioactive substance; it equals the radioactive half-life (q.v.) multiplied by 1.443.

Avogadro's law

Equal volumes of all gases contain the same number of molecules, assuming that conditions remain the same.

a.w.u.

The symbol for atomic weight unit (see ATOMIC WEIGHT*).*

axes of an ellipse

see MAJOR AXIS, MINOR AXIS.

axis of rotation

The straight line, real or imaginary, passing through a rotating body and which is the line about which that body rotates.

azimuth

The distance, measured in degrees, along the horizon, westward from the south point of the horizon, to the place where a vertical circle through the star, or other object, intersects the horizon.

It may be anything from 0° for a star directly south, 90° for one exactly west, 180° for one in the north, to 359° for one that is one degree east of south.

Nautical azimuth is the direction of an object from the observer, or the arc of the horizon between the north point and the vertical circle of the body, measured to the right or clockwise from true north through 360°. It is also the angle at the zenith between the northern part of the meridian and the vertical circle, measured in the same way. Azimuth is always expressed in three digits.

azimuth angle

The arc of the horizon between the meridian and the vertical circle of an object, measured either from the north or south, to the right or clockwise or to the left or counterclockwise, through either 90° or 180°. It must be labeled north or south as a prefix and east or west as a suffix to indicate direction of measurement.

azimuthal equidistant projection

Representation of part of the earth's surface or of the sky in which radial lines from a point of tangency represent great circles, and concentric circles, equally spaced, represent equal distances from the point of tangency. Angles are not correctly represented, meridians and parallels are curved lines, unless the point of tangency is a pole, in which case meridians are radial straight lines, and parallels are concentric circles. The distance scale is constant along the great circle radii. Used in polar navigation, navigation about a given airport or seaport, and also for star charts and finders.

azusa system

(ASTRONAUTICS) An apparatus that measures the velocity and position of a GUIDED MISSILE (q.v.) in flight.

B

back out

Reversing a count-down procedure to postpone launching.

background

In the terminology of instrumentation certain constantly present effects in physical apparatus above which any phenomenon must manifest itself in order to be measurable

background continuum

see STORM BURST

background count

In radiation measurement, any COUNT (q v) caused by any other event or process than the one intended to be detected or measured

backscattering

The deflection of particles or radiation by scattering processes through angles greater than 90 degrees with respect to the original direction of motion (Also *called* back scatter.)

Baily's beads

During an eclipse of the sun for a very few seconds, just before and just after totality the light from the edge of the sun shines through the valleys between the mountains on the moon and gives the appearance of a string of beads

If it happens that only one "bead" shows very brightly it displays what is called the diamond ring effect

Balfour-Stewart currents

Electric currents above the surface of the earth, named for the scientist who was first to mention them.

ballistic missile

(ROCKETRY) A missile powered during the initial stages of its flight; after its power is off, it "arcs over" into a high curving trajectory.

ballistics

The science of missiles and projectiles and their motion.

balloon

In general, any bag made of some flexible, light material and inflated with a gas lighter than air to make it rise and remain airborne by its own buoyancy.

Balmer Series

About 1885 it was discovered that the hydrogen lines in the spectrum of a star occurred in a series that seemed to run closer together toward the ultra-violet end. The Balmer Series is the series of lines in the visible portion of the spectrum

Balmer, a Swiss mathematician, worked out a formula for computing the wave lengths of the various lines in the series.

band

In spectroscopy and spectrum analysis, this term is applied to the set of closely spaced spectral lines produced by molecules of one kind under certain conditions. (*see* BANDS IN SPECTRA.)

band spectrum

A spectrum giving the appearance of bands, usually found in the spectra of molecules.

bands in spectra

The spectra of red stars show broad bands as well as dark lines.

For stars of spectral classes K and M they are caused by titanium oxide.

Classes R and N show carbon bands and sometimes the titanium oxide bands are absent.

The rare class S stars contain bands of zirconium oxide and usually of titanium oxide also.

barn

A unit of area used in expressing nuclear cross sections. 1 barn equals 10^{-24} cm^2. Symbol: *b*.

Barnard's Star

In 1916, Barnard, an American astronomer, discovered a 10th magnitude star that has the largest known proper motion. It moves across the sky at the rate of 55 miles per second, and changes its position with respect to its neighbors by 10.3 seconds a year. This would move it the apparent diameter of the moon in 180 years.

It is one of the nearest stars, being only 6.1 light-years from the sun. It is among the very faint stars for it gives only 4/10,000 as much light as the sun.

It is often called the *Runaway Star*.

barograph

A recording BAROMETER (q.v.).

barometer

An instrument for measuring atmospheric pressure, consisting essentially of a column of mercury or an aneroid cell.

barred spiral

The designation of those SPIRAL GALAXIES (q.v.) the two coils of which emerge abruptly from the ends of a bright bar projecting from the opposite sides of the central portion. They are classified as *Class SBa*, *Class SBb* and *Class SBc* spirals, according to the relative sizes of their central regions and arms and to the configurations of the arms: the central region is largest in the *Class SBa* spirals and smallest in the *Class SBc*, whereas the arms are thinnest and most closely coiled in *Class SBa*, heavier and more open in *Class SBb*, and thickest and most widely open in the *Class SBc* spirals.

barycenter

The center of gravity of the Earth-Moon system; generally, the center of gravity of any set of revolving masses.

base line

An accurately measured line to which all other measurements, usually of angles only, are referred; forming the reference line in a triangulation.

For triangulation. Two points are selected, a measured distance apart. Observations of a third point are made from both ends of this base line, and its direction is very carefully measured. From these a triangle can be constructed, by trigonometry, and the distances to the third point accurately computed. This is used for making maps of parts of the earth's surface.

For the Moon's distance. The base line must be long. We can use two observatories in distant cities if we know the distance between them. Measure accurately the direction of the moon from each of them at exactly the same time, and then construct the triangle. A better way, used now, is to make two observations from the same observatory, just twelve hours apart, so the base line is the diameter of the earth which is known quite accurately.

For star distances. No base line on the earth is long enough. The one used is the diameter of the earth's orbit, of 186 million miles. Observations are made just half a year apart, when the earth has travelled half way round the sun. This is measuring the parallax of the star. From that its distance can be computed. (*see* PARALLAX.)

beam

A unidirectional, or more or less unidirectional flow of radiation or particles.

beam intensity

The FLUX DENSITY (q.v.) of a beam.

beam interferometer

A giant, modern version of the STELLAR INTERFEROMETER

(q.v.), used at Mt. Wilson in connection with the 100-inch Hooker telescope. It consists of a steel beam, 50 feet in length, that carries two pairs of mirrors; the two mirrors nearest to the telescope are fixed in position, the two outer ones are movable. Light from the edges of the star viewed impinges on the two outer mirrors and is reflected to the two fixed mirrors, which reflect it to the objective of the telescope; the two light beams enter into interference with each other, and INTERFERENCE FRINGES (q.v.) are produced. The configuration and appearance of the fringes changes as the outer mirrors are moved, and the diameter of the star viewed can be calculated from the distance between the movable mirrors at which the fringes eventually disappear. (Only a few stars present angular diameters sufficiently large to be measured in this manner. The sizes of the others are calculated from their distances and magnitudes.)

bearing

The direction of an object from an observer, measured in angles.

beep

A colloquial term for an audible TELEMETERING (q.v.) signal.

beeper

(ASTRONAUTICS) Colloquial term for a person who operates and guides a missile or unmanned rocket craft by remote control.

Bellatrix

The traditional name of the star γ Orionis (*see* STARS—*Plate X*).

Benetnasch

The traditional name of the star η Ursae Majoris, one of the stars in the Big Dipper. More commonly known as ALKAID.

beta decay, beta disintegration

The radioactive transformation of a substance, by which the

atomic number changes by $+1$ and the mass number remains unchanged.

beta emitter

An atom that radiates BETA PARTICLES (q.v.).

(Beta) Lyrae-type variables (β Lyrae-stars)

see BRIGHT ECLIPSING VARIABLES, ECLIPSING VARIABLES.

beta particle

The negatively charged electron emitted by certain radioactive nuclei. (*Also called* BETA RADIATION and BETA RAY.) The term, *positive beta particle*, is used to denote a *positron* (positively charged electron).

Beta Persei

see ALGOL.

beta radiation, beta ray

see BETA PARTICLE.

betatron

An instrument in which electrons, sometimes called "beta particles" whirl rapidly in a changing magnetic field, gaining in speed while the field increases. They are then used in atom probing experiments.

Betelgeuse

The traditional name of the red variable star α Orionis, in the right shoulder of Orion. (*see* STARS—*Plate X*.)

Bev

The abbreviation for *billion electron volts*.

Biela's Comet

A small comet, a member of Jupiter's family, with a period of 6.6 years, discovered in 1826 and seen to return several times.

In November 1846 it appeared as usual. A month later it became pear shaped and then divided into two comets, each

with a short tail. The two travelled side by side, at a distance of 160,000 miles apart, for more than four months.

When they returned in 1852, both twins were seen, but about 1½ million miles apart. They have never been seen since, although they should have returned more than a dozen times.

Bielids

see ANDROMEDIDS

bifid

Said of the tail of a comet that appears to be split lengthwise into two parts or branches

Big Dipper

A group of seven, second-magnitude stars which form a part of the constellation of Ursa Major the Great Bear It is the best known and most easily recognized asterism in all the sky

Five of the stars excepting those at the tip of the bowl and the end of the handle together with a number of others in distant parts of the sky form a large open cluster all moving in the same direction and approaching the sun at speeds of 15 to 20 miles per second

Because the two end stars are moving in almost the opposite direction the dipper will not look like a dipper 50 000 years from now

The star MIZAR at the crook of the handle has a small companion, ALCOR, near it that has been used for hundreds of years as a test of eyesight It is not a difficult test, for most people can see the little star Mizar is a telescopic double and both its parts and Alcor are spectroscopic doubles, so there are really six stars there instead of two.

The stars of the dipper are from 70 to 80 light years distant from the earth

This group is very ancient. It is mentioned in the Book of Job as "the seven stars" It was used by ancient navigators to

mark the north, before they discovered that Polaris was much closer to the north pole of the sky.

The dipper is called the "plough" in England, and the "wagon" or "wain" in some European countries.

There are two other "dippers" in our sky. The Little Dipper, is the constellation of Ursa Minor, the Little Bear; the Milk Dipper is in the constellation of Sagittarius, far to the south in our summer sky.

binary stars

Two stars close together and revolving around their common center of gravity.

The first was discovered by Herschel in 1803 when he proved the mutual revolution of Castor. There are three distinct classes.

Visual binaries, when the two stars can be separated with a telescope.

Spectroscopic binaries, when the stars are so close together that the telescope can not separate them, but the spectroscope shows the periodic oscillation of their spectral lines.

Eclipsing binaries, when the orbits of revolution are so nearly edgewise to the earth that the two stars eclipse each other.

Visual doubles were known as long ago as 1650 when Riccioli, an Italian, saw that Mizar, in the Big Dipper, was two stars. A few others were seen, but their study began in 1779 when Herschel started a catalogue of several hundreds. A new catalogue (1932) lists 17,180 visible from the United States, and there is a supplement for the southern skies.

The real proof that a pair of stars is a binary is that they have the same proper motion and that their revolution can be observed. This requires a long time. Therefore arbitrary limits to their distance have been adopted, 200″ for first magnitude, 20″ for sixth and 3″ for the tenth. (*see* AITKEN'S CRITERION.)

The stars revolve in elliptical orbits, with periods varying from 2 to several thousands of years. In some systems the two stars are little farther apart than the earth and the sun. In others they are hundreds of times farther than from the sun to Neptune.

When the orbits of a binary have been calculated and its distance is known, the masses of the stars can be calculated. The masses of the majority are not less than 1/5 nor more than ten times the mass of the sun.

Spectroscopic binaries were first discovered in 1889 when Mizar was found to show double lines in its spectrum at some times and not at others. If the separation of two stars in a system is less than .1 of a second, no present telescope can show them as two stars. The spectroscope can show them when they are almost in contact with each other.

The 1936 Catalogue of Spectroscopic Binaries lists 1420 pairs and gives the orbits of 375.

The periods are short, ranging from a few hours to a few years. For the majority they are less than 10 days.

From measurements of the spectral lines it is possible to calculate the velocity of the orbital motion and sometimes to plot the orbits.

It is believed that at least a quarter of all the stars are double or multiple. Quite often there are more than two in a system.

Their orbits vary from almost circles to very long ellipses.

Their separation varies from almost contact to so far that they can be recognized only by their common motion through space.

If the two stars are of the same brightness they are usually the same color. If not, their colors may be very different.

The theory generally accepted for the formation of double stars, is that a large star shrinks, rotates faster, becomes flattened and finally separates into two stars. This has not yet been proved.

Eclipsing binaries. When the orbit of a spectroscopic binary is edgewise toward the earth, it is an eclipsing binary.

Several hundred are known. Their periods vary from a few hours to many months. In one case it is 27 years and the eclipse lasts about two years.

Sometimes, as in Algol, the eclipse is only partial. Sometimes it is total.

In most eclipsing systems the surfaces of the stars are not far apart in some cases they must be almost, if not actually, in contact. For the most famous eclipsing binary *see* ALGOL.

binocular

An instrument consisting of two similar telescopes, one intended for each eye of the viewer; the two telescopes are usually focused by a common screw device.

bioastronautics

ASTRONAUTICS considered for its effects upon animal or plant life.

biodynamics

The study of the motions of bodies and of the forces acting upon bodies in motion, or in process of changing motion, as these motions or forces affect life.

biologic half-life

The time that a given organ, tissue or species requires to eliminate half of a substance introduced into it.

biophysics

The study of physical phenomena displayed by living organisms or parts thereof; in general, the study of phenomena of living organisms by physical methods.

biosatellite

A satellite designed to carry an animal or plant, or a satellite that carries a man, an animal or plant.

biosphere

That part of the earth and its atmosphere in which animals and plants live.

bipropellant rocket

A rocket equipped with a ROCKET MOTOR (q.v.) into which the rocket fuel and the oxygen or oxidizer are injected separately; consequently, these rockets carry their fuel and oxygen supplies in separate tanks. (These rockets are exclusively of the liquid propellant class.)

bird

(ASTRONAUTICS) Colloquial term for GUIDED MISSILE (q.v.) or ROCKET.

birefringent filter

An instrument consisting of a color filter that transmits an extremely narrow band of wavelengths, utilizing birefringent crystals and polarizers. It was developed by Ohman and Lyot for monochromatic photographs of the sun.

bisect

To adjust the cross-hair of an observing instrument as a diameter of an image.

bissextile year (leap year)

When Julius Caesar put the extra day into February he put it just after Feb 23. The 24th was called "*sexto-calendar*" Mars, or the sixth day before the kalendar, or first of March. The new day every fourth year made two sixth days, and so was called *bissextocalendar* which gave the name to the leap year.

black body

An ideal, or imaginary, body which is absolutely black when cold, but is a perfect absorber of radiation and at the same time a perfect radiator.

It is used in working out the theoretical laws of radiation and in calculating the temperature of the sun.

black body radiation

Perfect radiation, such as would come from a BLACK BODY (q.v.).

black-drop

Elongation of image of a planet near internal contact with sun.

black-out

A temporary loss of vision, possibly also of consciousness, under the effect of high acceleration (positive or negative).

blast off

(ASTRONAUTICS) Colloquial term for the takeoff of a manned rocket.

blink comparator

An instrument for viewing two photographs of the stars in the same part of the sky but taken at different times.

It has a single eyepiece and a mechanism by which the two plates are hidden alternately three or four "blinks" a second. If a star is displaced on one plate it seems to jump back and forth, and thus attracts the observer's attention.

It is used to study the proper motion of stars, using plates taken several years apart. (*see* also STEREO COMPARATOR.)

blip

Deviation of light on a radar screen, caused by reflection of signal or disturbance.

blow-off

Separation of sections of a rocket vehicle.

blue magnetism

Polarity of the south-seeking end of a compass magnet. It is the magnetism of the north magnetic pole of the earth. (*see* TERRESTR' L MAGNETISM.)

blue of the sky

The air scatters the blue light of the sun, which makes the sky look blue. Longer waves of red and yellow are transmitted, which gives the red color of sunset and sunrise.

Bode's law

A statement of a relation between the mean distances of the planets from the sun, first published by the German astronomer Bode in 1722 although it had been recognized and mentioned by Titius several years before that (and hence referred to occasionally also as the *Bode-Titius rule*). It can be stated as follows: If we write a series of 4's and add 0 x 3 = 0 to the first one, 1 x 3 = 3 to the second one, 2 x 3 = 6 to the third one, etc., the resulting figures approximate very closely the distances of the successive planets from the sun, expressed in ASTRONOMICAL UNITS (A.U.)

4 +	0	4	Mercury	0.39
4 +	3	7	Venus	0.72
4 +	6	10	Earth	1.00
4 +	12	16	Mars	1.52
4 +	24	28	[Asteroid Belt (Ceres)]	2.77
4 +	48	52	Jupiter	5.20
4 +	96	100	Saturn	9.54
4 +	192	196	Uranus	19.19
4 +	384	388	Neptune	30.07
4 +	768	772	Pluto	29.00—42.00

The law is confirmed by the planets up to Uranus (considering the asteroids as a planet or the remnants of one between Mars and Jupiter) but it fails for Neptune and Pluto. It is however considered generally as a matter of coincidence, and devoid of any deeper significance.

body burden

In radiology, the amount of radioactive material present in the body at a given time.

Bohr's atom model

Niels Bohr of Denmark, constructed a mathematical model of an atom, showing a central nucleus with electrons revolving about it in various orbits. The distance of the orbits from the nucleus are proportional to the numbers 1, 4, 9, 16 . . . which are the squares of 1, 2, 3, 4. . . .

He explained the emission of light as the result of an electron falling from one orbit to another nearer the nucleus. Also light passing through an atom could be absorbed if on striking an electron, it drove it into a larger orbit.

boiloff

Loss of liquid propellant through vaporization.

bolide

A brilliant meteor, especially one that bursts into fragments near the end of its path in the earth's atmosphere; a FIRE-BALL (q.v.).

bolograph

A record, like a spectrograph, which shows lines far beyond the visible spectrum, in the infra-red.

bolometer

An electrical instrument for measuring and recording exceedingly minute changes of temperature. It depends upon the change in resistance of a very thin strip of metal when slightly heated or cooled.

It can be connected with a telescope or a spectroscope to measure the heat of the stars. It is very much more sensitive than any thermometer or thermopile.

bolometric magnitude

The MAGNITUDE (q.v.) of a celestial body as determined by the total amount of radiant energy of all wavelengths that reaches the upper surface of the earth's atmosphere. The zero of this scale corresponds to the VISUAL MAGNITUDE (q.v.) of a star of the spectral class G0.

Bomarc

A surface-to-air guided missile of the U.S. Air Force, powered by two ramjet engines (each of which delivers a thrust of about 10,000 lbs.) and equipped with a permanently attached liquid-propellant booster rocket. Effective cruising range 200-300 miles, velocity about Mach 2.5. Overall length (not including booster rocket) almost 40 feet, weight about 5000 lbs.

Bonner Durchmusterung (BD or DM)

A large star catalogue made by Argelander, a German astronomer. It gave, rather roughly, the position of 324,000 stars of the northern heavens. It was the largest catalogue ever made at the time of its publication.

Later Schoenfeld published a catalogue of southern stars under the same name.

These contain all stars down to about the 10th magnitude.

booster

(ASTRONAUTICS) A small rocket or other propulsion device attached to a larger missile or rocket (usually under the tail assembly) to assist it in its take-off, after which it becomes detached and drops off.

boost-glider

Combination of rocket and glider

Boötes [the Bear Driver or the Kite]

A large, kite-shaped figure with Arcturus at the bottom point of the kite.

It represented a man holding the leashes of two hunting dogs, Canes Venatici, and driving the Great Bear around the north pole every day.

Arcturus is one of the brightest stars in the northern sky, is about 100 times brighter and 27 times the diameter of the sun. It is 40 light years away.

bore

Where the wave of the tide enters narrowing channel

such as the mouth of a river, or a V shaped bay like the Bay of Fundy, it piles up and becomes a breaking wave. The nearly vertical front may be five or six feet in height and crested with foam.

Such a bore is very dangerous to small vessels.

Boyle's law

At a given temperature the product of the volume of a gas and the pressure is constant; otherwise stated, the volume of a fixed mass of a given gas at constant temperature is inversely proportional to the pressure; that is, the pressure of a perfect gas varies directly as the density and the temperature.

brain

(ASTRONAUTICS) A colloquial term for the guidance system of a missile or unmanned rocket.

braking orbit

(ASTRONAUTICS) A spiral-like flight path consisting of a series of successively smaller ellipses (called *braking ellipses*) described by a missile or rocket about the earth or another celestial body surrounded by an atmosphere preparatory to landing, in order to decelerate to a safe landing speed without expending much fuel on braking. As the rocket dives into the atmosphere in each braking ellipse, the air friction reduces its speed, then it swings out again into cold outer space to cool off before the friction could heat its hull to a dangerous degree; since each braking ellipse is smaller than the preceding one, each brings the rocket into successively denser layers of the atmosphere and for successively longer intervals.

braking rocket

(ASTRONAUTICS) Any of the rocket tubes installed in the tail assembly of a jet-propelled craft or missile; as the craft or missile descends tail-first for a landing, the breaking rockets are fired to slow it down sufficiently for a safe, smooth landing.

bremsstrahlung

The production of electromagnetic radiation by the acceleration of a fast electron (or other charged particle) as it is deflected by a nucleus or some other charged particle. The term is used also to denote the radiation resulting from this process.

brennschluss

(ASTRONAUTICS) The moment or process of the shutting off of all fuel valves in a rocket It does not necessarily imply that all fuel carried by the rocket has been consumed, merely the end of the action of the rocket motor. This German term is preferable to the expressions *allburnt* and *burnout* which are frequently used as synonymous with it

bright eclipsing variables

BINARY STAR SYSTEMS (q v) consisting of two luminous stars that revolve around each other and have the plane of their orbits, in our line of sight each eclipses the other one once during each revolution Thus there are two minima in each period, the depths of which depend on the relative brightness of the two bodies concerned Their periods are perfectly constant The best known star of this type is β Lyrae.

bright-line spectrum

A succession of bright, colored lines on a dark background. It is formed when the source of the light is a glowing gas, which broadcasts on a series of wavelengths characteristic of the chemical element of which the gas is composed. Each gaseous element gives its own pattern of lines in the spectrum.

Some of the nebulae give bright-line spectra

British thermal unit (Btu)

The quantity of heat required to raise the temperature of one pound of water one degree Fahrenheit at atmospheric pressure, 1 Btu equals approximately 25_ gram-calories.

Brooks' Comet

A short period comet that in 1886 passed very close to Jupiter, going between the satellites and nearly grazing the surface of the planet. Its period was changed from 27 to 6.8 years.

In 1921 it again passed close to Jupiter. The orientation of its orbit was completely reversed, and its period lengthened to 6.95 years. It was seen last in 1939.

Btu

The abbreviation for BRITISH THERMAL UNIT (q.v.)

burnout

(1) The event or action that marks the final combustion or oxidation of a fuel.—(2) The moment that this event takes place. (*see* BRENNSCHLUSS.)

burnout velocity

The velocity of a rocket at the end of propellant oxidation.

burn-up

(1) (ASTRONAUTICS) The vaporization of an artificial satellite or other rocket by aerodynamic heating in the earth's atmosphere. (*See* ORBITAL DECAY.)— (2) In nuclear engineeering, the fissioning of nuclear fuel, as in a nuclear reactor.

burst

(1) In cosmic ray studies, an exceptionally large electric pulse visible in an ionization chamber; it indicates the emission or incidence of several or many ionizing particles simultaneously. The cause of the phenomenon may be a COSMIC RAY SHOWER (q.v.) or a nuclear disintegration known as *spallation.*—(2) In radio astronomy, a sudden, very brief increase in the intensity of the radiation received. (*see* also STORM BURST.)

C

Caelum [the Sculptor's Tool]

A southern constellation.

calcium

A silvery-white, soft metal. It forms a part of marble and limestone. When heated it is a source of brilliant white light.

Clouds of shining calcium gas form a part of the light-giving surface of the sun.

There are immense clouds of calcium particles in the space between the stars.

calcium stars

The Class *F* stars (*see* SPECTRAL CLASSES), so named for the dominant lines in their spectra.

calendar

It is very difficult to make a good calendar because the natural divisions of time, the day, month and year, are not commensurable. Our calendar comes to us from the Romans, but is much changed from theirs.

Jewish calendar. The year began in the spring. There were 12 months of 29 and 30 days alternately. The year had only 354 days, and the calendar did not keep step with the seasons. To help adjust it they added a 13th month every 3 years. The month began on the day that the new moon was first visible after sunset.

Mohammedan calendar. The Mohammedan peoples still use the Jewish type of calendar only they do not put in the extra

month. As a consequence the months bear no relation to the seasons, and they lose one year in every 34.

Roman calendar. In ancient Rome the year began in March and there were only ten months. Six of them were numbered instead of named, and we still have four of them from September to December. Later they added February at the beginning of the year, and January at the end. They added an extra month occasionally, but with no definite rule.

Julian calendar. At the time of Julius Caesar, the vernal equinox was coming in December instead of March.

Caesar got an astronomer to measure the year as closely as he could. He reported that it was 365¼ days. So they made a calendar of 12 months of 30 days and 31 days except February which had only 28 days, and they began the year with January instead of March. To take care of the quarter of a day they added an extra day to February every fourth year.

That is where our leap year day came from. The calendar was first used in 44 B.C. and it lasted for over 1600 years.

But the Julian calendar year was 11 min. 14 seconds too long, and so the date of the vernal equinox slipped slowly backward from March 25 to March 21 in 325 A.D..

In that year the Council of Nicea was held to fix the date of Easter, and they decided that the equinox should always be March 21. But the seasons did not obey and by 1582 A.D. the equinox had fallen back to March 11.

Gregorian calendar. In 1582 Pope Gregory XIII revised the calendar once more and gave us the one that we use now. It is very nearly correct and has been adopted by nearly all of the nations of the world.

World calendar. Some people are advocating another change. They propose to keep the present 12 months but rearrange the days so that the year can be divided into four quarters that will be all alike. January, April, July and October would begin on Sunday and each have 31 days. The other months would have 30 days. This makes a year of 364

days. The 365th day would be called "year-end day," follow Dec. 30, but be in no month and be an extra Saturday. Leap-year-day would also be a Saturday and follow June 30.

This calendar would make every year like every other one. The dates would always fall on the same day of the week. Every month would have the same number of working days, or school days. Holidays would always be celebrated on Monday, giving us long week-ends.

see also ASTRONOMICAL CALENDAR

calendar day

One of the days of the CALENDER MONTH (q.v.)

calendar month

One of the divisions of the Gregorian calendar, comprising 28, 29, 30 or 31 days. (*see* CALENDAR.)

calendar year

see YEAR

Callisto

A satellite of Jupiter, (*see* SATELLITES OF THE SOLAR SYSTEM.)

calorie

The quantity of heat required to increase by 1 C the temperature of 1 gram of water at 15 C.

Camelopardalis [the Giraffe]

A northern consellation, also called *Camelopardus*.

canals of Mars

In 1877 Schiaparelli, an Italian astronomer, reported having seen some fine dark lines crossing the surface of Mars. He called them "canali," meaning *channels*. In the translation of his words into English, the word *canals* was used, suggesting artificial waterways instead of natural channels.

Percival Lowell, an American astronomer, believed they were really canals, dug by intelligent beings, to bring water from the melting polar icecaps for irrigation of the deserts on Mars.

Lowell drew a map showing over 400 canals, some of them more than 2000 miles long, intersecting in more than 200 "oases."

Photographs show some broad, hazy markings, but not fine, sharp lines.

No one believes now that they are canals, but we do not know what they really are. Perhaps strips of vegetation along old stream valleys.

Cancer [the Crab]

The fourth and least conspicuous of the constellations of the zodiac.

It lies between Gemini and Leo and contains no bright stars.

It represents the giant crab that seized the foot of Hercules when he was fighting the Hydra. Juno had it put among the stars.

Cancer contains the open cluster called the Praesepe, the "beehive" or the "manger," and the two asses.

One story says that during the battle between the gods and the giants, two asses brayed so loudly that they frightened the giants. The gods put them in the sky with a manger between them that is always full.

It gave its name to the Tropic of Cancer because the sun was in this sign at the time of the summer solstice, when it begins to move backward like a crab.

Cancer, Tropic of

see TROPICS.

candlepower

A unit for measuring the intensity of light. It is defined as the light of a 7/8 inch sperm candle burning at the rate of 120 grains per hour.

The international unit is the light emitted by 5 square millimeters of platinum at the temperature of solidification.

Measurements are now made with standard electric lamps.

candlepower of the Sun

The total candlepower of the sun is about 2.5×10^{27}.

To make that number of candles, even birthday-cake size, would require a lump of wax ten times larger than the earth. The candles set end to end would cover a cake as large as the earth's orbit.

Each square inch of the sun shines as brightly as 300,000 candles.

Canes Venatici [the Hunting Dogs]

A small constellation under the handle of the Big Dipper.

The only bright star is Cor Caroli, or Charles' Heart, named in England about 1725 in honor of King Charles I.

It is said that Charles II deserved the honor because he founded Greenwich Observatory. (*see* BOOTES.)

Canis Major [the Greater Dog]

South and east of Orion is this dog, unmistakably marked by Sirius the brightest star in all the sky.

Sirius is almost in line with the three stars in Orion's belt and is 20° from them. It is not a giant star, being only twice the diameter of the sun, but its temperature is very much higher and it gives about 27 times as much light. It is the nearest star that we can see from most of the United States. Its distance from the sun is 8.7 light years or 52 millions of millions of miles.

Sirius has a small, but very heavy companion revolving about it once in 49 years, at a distance of 1,800,000,000 miles. (*see* COMPANION OF SIRIUS.)

Canis Minor [the Smaller Dog]

A very small constellation directly east of Orion.

To the Egyptians it was the little dog that told them when the big dog was coming, for the rising of Sirius just before sunrise in the summer marked the annual overflow of the Nile.

It contains only one bright, 1st magnitude star, Procyon.

Procyon is the 8th brightest star in the sky. It is about 6

times as bright as the sun; its diameter is 2.3 times that of the sun and it is nearly 1000° hotter. It is 11.2 light years away.

cannibalization

(ASTRONAUTICS) A term, introduced by Arthur C. Clarke, for the proposed method of building a space station in space by assembling the payloads deposited by multistage rockets, and even using the orbit-reaching stages of the rockets for the construction.

Canopus

The traditional name of the star α Carinae (*see* STARS—*Plate X*).

Capella

The bright, first magnitude star α Aurigae (*see* AURIGA).

It is a spectroscopic binary with a rotation period of 104 days. The velocity of one star is 4/5 that of the other, therefore its mass must be 4/5 that of the other star. The two stars are about 79 million miles apart. They are 47 light years away from the earth.

Capricorn, Tropic of

see TROPICS.

Capricornus [the Sea Goat]

The tenth constellation in the zodiac, and next to Cancer, the least conspicuous. It lies far south of the equator, between Sagittarius and Aquarius, and contains no bright stars. It shows a large, very irregular triangle.

It is said to represent the god Pan, who was frightened by the monster Typhon, and jumped into the Nile. The part of him under water changed into a fish and the part above into a goat.

This constellation gave its name to the Tropic of Capricorn, because the winter solstice was here where the sun began to climb upward in the sky.

The planet Neptune was discovered among these stars, in 1846.

Captive firing

Testing of the propulsion portions of a rocket while it is held tightly in a testing gantry.

capture theory

It was formerly believed that the orbits of all comets were originally parabolic, and that those that are ellipses had been changed by the gravitation of some planet near which they had passed.

JUPITER'S FAMILY of about 40 comets (q.v.) is the most convincing argument for this theory.

It is also suggested that the outer satellites of Jupiter, and possibly of Saturn, may be captured asteroids.

carbon cycle

A series of THERMONUCLEAR REACTIONS (q.v.) releasing vast amounts of energy, that presumably occurs in the sun and other stars and is the source of the energy radiated by them. According to H. Bethe, the cycle that takes place in the stars with the capture of a hydrogen nucleus (a proton) by a carbon nucleus and consists of the following six nuclear transformations: (1) The carbon nucleus ($_6C^{12}$) captures the hydrogen nucleus ($_1H^1$) and changes into a nitrogen ($_7N^{13}$) nucleus, (2) the $_7N^{13}$ nucleus emits a positron and changes into another carbon isotope ($_6C^{13}$), (3) the $_6C^{13}$ captures another $_1H^1$ and becomes another nitrogen isotope ($_7N^{14}$), (4) the $_7N^{14}$ captures another $_1H^1$ and becomes an oxygen ($_8O^{15}$) nucleus, (5) the $_8O^{15}$ nucleus emits a positron and becomes still another nitrogen isotope ($_7N^{15}$), (6) finally, this $_7N^{15}$ captures another $_1H^1$ and changes into the same carbon isotope ($_6C^{12}$) which started the cycle, plus a helium ($_2H^4$) nucleus. Thus, in the course of the process (the duration of which is roughly 6.5 million years) four hydrogen atoms are captured, one helium atom and two positrons are liberated, and the original carbon ($_6C^{12}$) atom that started the cycle is restored in the final step, to start the next cycle, as a catalyst as it were. the net result of the six-step cycle therefore is the

transformation of four hydrogen atoms into a helium atom, with a loss of about 1 per cent of mass which is liberated as energy.

carbon dioxide (CO_2)

About 1/2000 of the weight of the earth's atmosphere is composed of this gas. It is used by all green plants, the carbon taken out to form wood and the oxygen returned to the air.

The atmosphere of Venus contains about 10,000 times as much CO_2 as does the atmosphere of the earth. In such quantity it would be poisonous to animal life as we know it.

In the light of comets the spectroscope shows other compounds of carbon, especially carbon monoxide, CO, methane, CH, and cyanogen, CN.

carbon stars

The stars grouped in the SPECTRAL CLASSES (q.v.) *R* and *N*.

cardinal points

(1) *of the compass*: The four principal points, north, south, east and west.

(2) *of the ecliptic*: The vernal and autumnal equinoxes and the summer and winter solstices.

Carina [the Keel]

A part of the constellation ARGO (q.v.), regarded by many astronomers as a separate constellation.

Cassegrainian reflector

A reflecting telescope having a hole in the center of the large mirror and a small convex mirror near the center of the tube, which reflects light through the hole. The eyepiece is below the end of the tube and in line with it.

Several of the largest reflectors are mounted in this way. In some there are other mountings that are interchangeable.

Cassini's Division

The dark line that separates the outer ring of Saturn from the bright ring. (*see* RINGS OF SATURN, and SATURN.)

It is a space about 3000 miles wide where the small bodies of which the rings are composed can not revolve because of the disturbing gravitation of the larger satellites.

There is a similar, but fainter division between the bright and the Crepe rings.

A faint one, called ENCKE'S DIVISION, splits the outer ring into two. Very faint ones have sometimes been seen in the bright ring.

Cassiopeia, the Queen

Five bright stars in the shape of a W, directly across the pole from the handle of the Big Dipper and the same distance from it.

Named for the queen of Ethiopia who bragged that she was more beautiful than the sea nymphs and was forced by Neptune to sacrifice her daughter Andromeda to Cetus the sea monster.

Eta Cassiopeiae is a fine double star that can be separated by a 3 inch telescope.

A very brilliant nova appeared here in 1572 and was observed by Tycho Brahe. (*see* TYCHO'S STAR and ANDROMEDA.)

Castor

The nearly first magnitude star in the head of one of the Twins. (*see* GEMINI.)

This star is a beautiful double in a small telescope. The components are 6 seconds apart.

Each of the two stars is a spectroscopic binary, making four stars where the naked eye sees but one.

73 seconds away the large telescopes show a faint, ninth magnitude star which is at the same distance as Castor and moving at the same speed in the same direction. It is supposed to be a companion star revolving about the other four in a period of more than 10,000 years.

This faint star is also a spectroscopic binary.

That makes Castor a multiple system of six stars.

catalyst

A substance, in the presence of which chemical changes take place, without any change in the substance itself.

celestial body

A general term for all the objects that can be observed in the sky beyond the atmospheric envelope of the earth: the sun, the moon, the planets and their satellites, meteors comets, stars, nebulae and external galaxies.

celestial coordinates

see COORDINATES.

celestial coordinator

In nautical astronomy and aerial navigation, a universal diagram on the plane of the observer's meridian, adjustable to any latitude, showing at once the relations existing between altitude, azimuth, declination and hour angle of any heavenly body, and how any particular body moves through the sky.

celestial equator

The great circle of the celestial sphere all points of which are 90° from the poles It is the plane of the earth's equator projected onto the celestial sphere. Also called the EQUINOCTIAL.

celestial globe

A globe representing the celestial sphere. On it are marked the equator and the ecliptic, the stars and the constellations.

Tycho Brahe constructed a large and very famous one and plotted on it the positions of a thousand stars.

In using such a globe, it is set so that the altitude of the pole equals the latitude of the observer. Then it is rotated until the hour circle that has the same right ascension as the meridian coincides with the meridian. Then the relations of the celestial sphere to the horizon at the particular time will be correct.

celestial guidance

The guidance of a missile or vehicle by reference to celestial bodies

celestial horizon

The great circle of the celestial sphere every point of which is 90 from the zenith and the nadir It is the intersection of the sensible and rational horizons at infinity

celestial latitude

The distance of a star or planet north or south of the ecliptic measured in degrees along a circle of latitude

It is seldom used now It has been replaced by the declination which is measured from the equator instead of the ecliptic

(Celestial latitude is *not* analogous with terrestrial latitude!)

celestial longitude

The distance on the CELESTIAL SPHERE (q v) east or west of the EQUINOCTIAL COLURE (q v) which passes through the vernal equinox i e the arc of the ecliptic included between the vernal equinox and the foot of the circle of latitude passing through the given star or planet It is measured always eastward from the vernal equinox completely around the ecliptic, from 0 to 360 The lines corresponding to meridians are called HOUR CIRCLES (q v The celestial longitude is similar to the RIGHT ASCENSION (q v) which is measured along the equator instead of the ecliptic It is seldom used nowadays the right ascension being used instead (Celestial longitude is *not* analogous with terrestrial longitude!)

celestial mechanics

That branch of ASTRONOMY (q v) which deals with the motions of celestial bodies under the forces of gravitation. Also called *gravitational astronomy* and *mathematical astronomy*.

celestial meridian

A projection of a MERIDIAN (q.v.) of the earth onto the CELESTIAL SPHERE (q.v.): the celestial meridian of any place on earth is the GREAT CIRCLE (q.v.) of the celestial sphere that passes through the celestial poles, zenith, and nadir and intersects the horizon exactly north and south. The celestial meridian of a point remains fixed with relation to it. The term *the meridian* as customarily used denotes the UPPER BRANCH (q.v.) of the meridian, whereas the LOWER BRANCH (q.v.) is specified as such.

celestial navigation

The science and technique of guiding a ship or aircraft based on readings of the positions of celestial bodies. (*see* NAUTICAL ASTRONOMY.)

celestial navigation system

The control and correction of the course of aircraft, guided missiles or rockets by the automatic adjustment of the trajectory or flight path through the corrective actions of electronic computers on the basis of data fed into them by automatic tracking telescopes trained at certain stars.

celestial poles

The points at which the earth's axis, extended, intersects the celestial sphere. The altitude of the celestial pole always equals the latitude of the observer, and also the declination of the zenith of the observer.

celestial sphere

An imaginary sphere of infinite radius, concentric with the observer, on which all celestial bodies except the Earth appear to be projected. A conventional representation of the sky, useful in astronomy for many purposes in which the distances of the stars need not be taken into account. The *apparent place* of a celestial body on this imaginary sphere is the point where the line of sight, from the observer's eye, to the body,

pierces the sphere; the *true place* of the same body on the celestial sphere is the point in which a line from the center of the earth through the body pierces the celestial sphere.

celestial triangle

Navigational triangle when measurements are made on celestial sphere.

(*see* ASTRONOMICAL TRIANGLE.)

celo-navigation

NAUTICAL ASTRONOMY (q.v.).

Centaurus [the Centaur]

A southern constellation.

center of galaxy

see GALACTIC CENTER.

center of gravity

That single point where the entire mass of a body or a system may be assumed to be concentrated and to act. It is coincident with the CENTER OF MASS.

center of mass

That point within a body or a system through which the resistance owing to the body's inertia acts as it is accelerated. This point is coincident with the CENTER OF GRAVITY.

Centigrade scale

The scale used for thermometers by most scientific laboratories.

0°C = 32°F = 273°K, the freezing point of water.

100°C = 212°F = 373°K, the boiling point of water at sea level.

central eclipse

An unusual eclipse of the sun, when the point of the moon's shadow barely reaches the earth.

Theoretically the eclipse is total for a second or two, but practically it is annular. Baily's beads form a complete necklace, spoiling the total phase and concealing the corona.

central force

A force attracting to, or repelling from, a certain point, fixed or moving.

centrifugal effect on weight

The earth's rotation lifts objects on its surface so that they would weigh less at the equator than at the poles, by 1 pound in 289, if the earth were a sphere.

Owing to the earth's oblateness, the actual reduction in weight is greater than this by about one pound in 550.

centrifugal force

The force that compels a revolving body to recede from the center about which it revolves. It is equal, but opposite in sign to the CENTRIPETAL FORCE (q.v.) and the perfect balance of the two forces is what keeps a revolving body in its orbit. (*see* ARTIFICIAL GRAVITY.)

centripetal force

The force which draws a revolving body toward the center about which it revolves, thus restraining it from flying away in a straight line. It is equal, but opposite in sign, to the CENTRIFUGAL FORCE (q.v.).

cepheid variables

A subdivision of the VARIABLE STARS (q.v.), consisting of pulsating stars which increase in brightness as their areas increase and become dimmer again as they collapse to a smaller size. They were so named for δ Cephei, the first of their type to be recognized as such. They are different in color, and their periods of variation range from the short periods, measurable in hours, of the RR LYRAE (or CLUSTER-TYPE) VARIABLES (q.v.) to over 50 days. Those with periods of more than a day are referred to as the *cepheid variables proper* (also called *typical* or *classical cepheids*). They are yellow supergiants, of the spectral classes *F* and *G*, and they are very rare (their occurrence is considered to be about one among a million stars). Their variations of about one magni-

tude are surprisingly regular. Their brightness increases very rapidly and declines more slowly; they become bluer as they grow brighter, redder as they grow dimmer indicating that their temperature rises and decreases with their light. These PULSATING STARS (q.v.) alternately expand and collapse. Over-cooled by expansion, the star contracts and the contraction, under the action of gravity, produces the excess of heat that makes it expand again.

In studying these stars, a *remarkable relation* was discovered between their magnitudes and their periods. The brighter the star the longer its period.

Therefore as soon as the period of variation is observed, it is possible to calculate the absolute magnitude of the star, and from that to calculate its distance.

This is a very useful way of measuring distances, because all of the cepheids are too far away to show a measurable parallax

Many cepheids are known in the globular clusters and in exterior galaxies, and they make possible the calculation of the distances of these far-off groups of stars

In our galaxy the typical cepheids are either in the Milky Way or in a narrow band on either side of it.

(*see* PERIOD-LUMINOSITY RELATION)

Cepheus [the King]

A large northern constellation, between Cassiopeia and Draco, but containing no bright stars

It represents the king of Ethiopia, husband of Cassiopeia and father of Andromeda, who figure in the stories of the Royal Family.

Its most important star is one of three in the king's crown, called Delta Cephei, which is the original Cepheid variable, or pulsating star Its period is 5 days 8 hours 47 minutes, and it is easily seen by the naked eye.

The three brightest stars, Alpha, Beta, and Gamma, will become pole stars, in reverse order, in 4,500 6,000 and 7,500 A.D.

Cerenkov counter

An instrument designed to detect and register high-velocity sub-atomic particles by reacting to the CERENKOV RADIATION (q.v.) produced by them. Also called *Cerenkov detector*.

Cerenkov radiation

Radiation in the visible light range, produced when charged sub-atomic particles traverse a transparent medium with a velocity exceeding that of light in that medium. Also called *Cerenkov effect*.

Ceres

see ASTEROIDS.

cermet

The designation of various fused combinations of ceramics and metals. Being highly heat-resistant, cermets are used in astronautics where such quality is required; they are, however, by far not resistant enough to protect rockets from the tremendous temperatures that they must withstand when executing a re-entry into the earth's atmosphere.

Cetus [the Whale]

A large constellation between Aries and Eridanus, in the southwestern sky on autumn evenings It contains two 2nd magnitude stars.

It represents the sea monster sent by Neptune to devour Andromeda and punish Cassiopeia.

The only remarkable star in this group is Omicron Ceti always called MIRA (q.v.). It is a long period variable, changing in about 11 months from 3d to 9th magnitude When faint, it is far below naked-eye visibility.

chain reaction

A self-sustaining reaction, i.e., one in which one of the agents necessary to the reaction is itself a product of the reaction and proceeds to set off other identical reactions.

Chamaeleon [the Chameleon]

A southern constellation.

characteristic velocity

(ASTRONAUTICS) The sum total of all the velocities that a rocket has to develop or dissipate by fuel consumption in the course of a given, specific journey.

charge

(ASTRONAUTICS) A synonym for GRAIN (q.v.).

Charles' law

The volume of a given mass of a gas at constant pressure is increased by 1/273 of its volume at 0°C for each degree rise in temperature. (Also known as Gay-Lussac's law.)

chart

Representation on a flat surface of a curved surface; as for example, charts of the earth or Moon, or of the stars on the celestial sphere. Emphasis is on coordinates, and distortion is secondary in importance. (Cf PROJECTION, MAP)

chemical composition of the Sun

More than 60 of the chemical elements have been positively identified in spectra of the sun. Some have not been found, perhaps because they are so heavy that they are deep in the interior of the sun and their gases do not rise to the surface; or some of the lighter elements may give light that far in the ultra-violet part of the spectrum which we can not see.

Very few chemical compounds can exist there because of the very high temperature. Bands of titanium oxide, and a few other compounds, are found in the spectra of cooler sunspots.

Russell gives the following tentative composition of the atmosphere of the sun.

Percentages by volume:

hydrogen .91, helium .03, oxygen .03, metals .02, free electrons .01.

Percentages by weight:

hydrogen .46, helium .06, oxygen .24, metals .24.

His tentative determination of the relative abundance of the metals is:

magnesium .359, iron .239, silicon .143, sodium .095, potassium .060, calcium .048, aluminum .014, nickel .014, manganese .010, chromium .006, cobalt .006, titanium .002, copper .002, vanadium .001, zinc .001.

chemical compounds

In Comets. Several carbon compounds have been identified. (*see* CYANOGEN IN COMETS.)

In Sunspots. In the spectra of sunspots there are lines due to compounds of titanium, magnesium and calcium.

In Sun's Atmosphere. Many faint lines are identified with compounds, especially titanium oxide.

In Red Stars. The spectra of stars beyond class *K* show lines of titanium oxide and zirconium oxide.

chemical elements

A substance that cannot be decomposed into simpler or more elementary substances by chemical means. Defined in nuclear physics as a substance all the atoms of which have the same atomic number, i.e., the same number of electrons circling its nucleus.

chemical energy

The energy released in a chemical reaction.

chemosphere

A stratum of the atmosphere considered to begin at approximately 20 miles and to extend to 50 miles above the earth, marked for its photochemical activity. (Some meteorologists consider the chemosphere to be an extension of the stratosphere.)

chondrite

A type of the stony meteorites known as AEROLITES, characterized by the presence of CHONDRULES (q.v.).

chondrule

A peculiar rounded granule, usually consisting of enstalite or chrysolite. Sometimes found embedded in stony meteorites. (*see* CHONDRITE.)

chromatic aberration

A lens defect that results in the formation of several images of different sizes and colors by a lens owing to the different degrees of the refraction of the different wavelengths that make up white light. This defect can be corrected by the use of an ACHROMATIC LENS (q.v.).

chromosphere

The layer of the sun's atmosphere above the reversing layer and below the CORONA (q.v.). It is of a brilliant red color. It is several thousands of miles in thickness. Above it the prominences rise to heights of tens of thousands of miles.

chromospheric eruption

A SOLAR FLARE (q.v.).

chronic exposure

Irradiation over a long period of time

chronograph

An instrument for recording the exact time that an event occurs.

Usually it is a revolving cylinder covered with paper on which a pen traces a continuous spiral line. An electrical connection causes the pen to make a small mark at the end of every second.

When an observer wishes to record the time of something, as when a star crosses the meridian line in his telescope, he

presses a key that makes a different mark on the paper, and so has a record of the exact time.

chronometer

Measurer of time. A large, very carefully made watch used to keep very accurate time. Used mostly on ships. It is usually mounted on gimbals, so as to remain horizontal at all times regardless of the motion of the ship. It keeps Greenwich mean solar time.

All ships carry one or more. Navigation is impossible without accurate time. Their use is less necessary now than formerly, because of radio time signals.

Circinus [the Compasses]

A southern constellation.

circle of equal altitude

Circle drawn on the earth to represent the points at which, at any given instant, the altitude of a celestial body is the same.

circle of equal declination

A small circle of the celestial sphere connecting all points of the same declination, similar to a parallel of latitude on the earth.

circle of illumination

The line dividing the illuminated half of the earth from the half that is in darkness.

circle of perpetual apparition

A small circle of the celestial sphere, the radius of which equals the latitude of the site of observation; all celestial bodies the declination of which places them within this circle appear circumpolar to the observer, i.e., never sink below the horizon. (At the terrestrial poles all visible stars are within this circle, whereas at the terrestrial equator there is no such circle.)

circle of perpetual occultation

A small circle on the celestial sphere, so situated to the observer that the celestial bodies the declination of which places them within this circle never appear above the horizon at the site of observation. (Cf. CIRCLE OF PERPETUAL APPARITION.)

circle of position

In finding the position of a ship at sea, observations are taken of the positions of two known stars above the horizon. By subtracting the measures from 90° one gets the distance of the stars from the zenith. Tables in the Nautical Almanac give the positions on the earth where these stars are exactly at the zenith. By using the substellar points as centers and the zenith distance as radius, two "circles of position" can be drawn on a chart. Since the ship is on both of these circles, it must be at one of their points of intersection. A third such circle establishes a definite position.

circles of latitude

Great circles on the celestial sphere drawn through the poles of the ecliptic and perpendicular to the ecliptic.

They are seldom used now, having been replaced by meridians and hour circles.

circular motion

If a body is moving about a center under the action of a central force, and the force is constant, the path, or orbit, of the body will be a circle.

circular orbital velocity

(ASTRONAUTICS) The velocity which enables a rocket to rise from the earth and to circle it in an orbit, as an artificial satellite, indefinitely, but without attaining the VELOCITY OF ESCAPE (q.v.) necessary to escape the earth's gravitational attraction completely. Also referred to simply as ORBITAL VELOCITY.

circumlunar rocket

Vehicle designed to return to earth after going around moon.

circumpolar star

A star that never sets at the latitude of the observer, because it is nearer to the elevated pole than the pole is to the horizon; it circles the elevated pole once every sidereal day. (See *Plate I.*)

cislunar space

Space around the Earth within the Moon's orbit.

civil day

see DAY.

civil time

The same as mean solar time. Time measured by the mean, or average, sun which is imaginary and supposed to move along the equator instead of the ecliptic.

It is the basis of standard time, the time that we use. (*see* TIME.)

civil twilight

The period before sunrise or after sunset during which the center of the sun is not more than 6° below the horizon. (*see* TWILIGHT.)

classification of stars

see STAR, SPECTRAL CLASSES and TYPES OF STARS.

clepsydra

A WATER CLOCK (q.v.).

climate

Average weather, at a particular place, over a period of many years.

climatic zones

The five zones determined by the inclination of the earth's axis to the plane of its orbit.

Frigid Zones Within 23½° of the poles, where the sun becomes circumpolar and the seasons are extreme

Torrid Zone Bounded by the tropics of Cancer and Capricorn, 23½ from the equator, the sun may be in the zenith at noon, day and night do not greatly differ, temperature changes are not extreme

Temperate Zones Between the frigid and the torrid zones The sun can never be either in the zenith nor circumpolar, temperatures vary widely and seasons are definitely marked.

clock star

Any star used in measuring time and for determining errors in astronomical clocks Clock stars are bright stars of well known right ascensions (q v)

clocks

Modern instruments for measuring time

Sun dials water clocks and sand glasses were used by ancient peoples

Mechanical clocks became possible after Galileo discovered the use of a pendulum The earlier clocks were large mounted in towers and churches had only one hand and were driven by weights

Steel springs made possible smaller clocks and then watches.

Driving clocks were used until very recently, to move telescopes so that a star could be kept in the field for long time Electric motors now do this work better. (*see* ASTRONOMICAL CLOCK)

Clouds of Magellan

see MAGELLANIC CLOUDS

clouds of stars

The Milky Way is made up of clouds of stars so faint and far away that we can not see them as separate stars

The brightest clouds in it are in Sagittarius and Scutum, far south in our summer evening sky

These clouds are estimated to be about 6,000 light-years distant. The center of our galaxy is thought to be far beyond them, hidden from us by the dark clouds in this part of the Milky Way.

cluster of galaxies

Just as there are clusters of stars in our galaxy, so beyond it there are clusters of external galaxies.

There are 20 known clusters, each containing around 500 members, ranging through about 5 magnitudes in apparent brightness. They do not vary greatly in size. They include more elliptical than spiral systems, although outside the clusters the spirals are in the majority.

The greatest of them is the VIRGO CLUSTER (q.v.).

Other important clusters are:

Cancer Cluster. Occupies a space about 4 times as large as the full moon and contains 150 galaxies.

Perseus Cluster. Covers a space 2° in diameter and has a membership of 500 galaxies, mostly elliptical. It lies a little east of Algol.

Coma Cluster. Only 3° from the north galactic pole. Contains 800 galaxies. Its diameter is 1.7°. There are 100 galaxies in a space the size of the full moon.

Ursa Major Cluster. About 300 galaxies in a small space within the bowl of the Big Dipper.

Leo Cluster. East of Regulus, in a space slightly larger than the moon, are 300 galaxies and probably many more that are too faint to be photographed yet.

Centaurus Cluster. Three hundred galaxies in an oval space as wide as the moon and five times as long.

cluster of stars

see STAR CLUSTER.

cluster-type cepheids, cluster-type variables

see RR LYRAE VARIABLES.

Coalsack

One of the most conspicuous of the dark nebulae. It is close beside the Southern Cross.

It used to be thought to be a hole in the Milky Way looking through into dark space where there were no stars. It is now considered a huge, black cloud, of dust or gas, that hides the stars behind.

There is a similar cloud near the Northern Cross, sometimes called the Northern Coalsack

coasting

(ASTRONAUTICS) The movement of a rocket or missile after its motor has ceased to operate.

coelostat

A form of telescope in which a moving mirror reflects the image of the object through a tube that is stationary.

It has some advantages over a telescope that must be moved to follow a star across the sky. One advantage is that it can be built longer without danger of bending. Another that the observer and his photographic apparatus can occupy a fixed position and the cameras need not move.

Sometimes the tube lies horizontal or it may stand vertical as a tower telescope. (*see* TOWER TELESCOPE.)

co-latitude

The complementary angle of the LATITUDE (q.v.) (*see* ASTRONOMICAL TRIANGLE.)

collimating lens

A lens employed in a spectroscope or spectrometer to make the light rays parallel.

collimation

The act or process of adjusting the line of sight of an optical instrument.

collimator

A device consisting of a tube containing a COLLIMATING

LENS (q.v.) and a screen with a slit, employed in order to make the rays of light parallel before they impinge upon the prism of a spectroscope.

collision

That which happens when one moving body encounters another.

The energy of motion is changed into some other form of energy, usually light or heat.

If the moving bodies are electrons or atoms various radiations result, such as x-rays.

If they are molecular, the result is an increase in the temperature of one or both bodies.

If the moving bodies are larger than molecules there may be destruction of one or both, and always generation of much heat.

Many people have worried about the possible collision of some other celestial body and the earth. The only possible ones are those with meteors and comets. Meteors collide with the earth every day. Most of them are so small that the heat, generated by friction in the air, burns them up before they reach the surface. Those that do fall are small and cause very little or no damage. There is no record of any person's having been killed by a meteorite.

The heads of comets are only swarms of meteor-like bodies. If one should collide with the earth, we would have a brilliant shower of meteors, possibly a large number of meteorites falling over a rather large area. Meteor Crater in Arizona is thought by some people to have been made by the fall of a small comet.

One theory of the formation of the solar system supposes the close approach or actual collision of another star and the sun. It is thought that the planets were made of material pulled by gravity or possibly blasted from the sun.

Such collisions may happen, but not often; possibly once in many millions of years.

Life here on the earth is in no danger from collision with any other celestial body.

collision hypothesis

The theory of Jeffreys of the origin of the solar system, which differs from the TIDAL THEORY (q.v.) in that it postulates that an actual collision took place between the approaching star and the sun. (*see also* DOUBLE-STAR COLLISION HYPOTHESIS.)

color excess

The amount, expressed in magnitudes, by which the COLOR INDEX (q.v.) of a star exceeds the accepted value for stars of the same spectral class.

Because of the absorption of starlight by clouds in space, a star that is 9,000 light-years away in the Milky Way, should have a color excess of a whole magnitude. If its spectrum is like that of the blue star Vega, it should have the color of the reddish star Aldebaran.

color index

The color index of a star is a measure of its color. It is the photographic magnitude minus the visual magnitude.

For the blue stars the color index is negative, for the red stars it is positive.

The color index of the white stars of the spectral type A0 is taken as zero and that of the K0 stars as unity.

The color index for Sirius, a white star, is 0. For Antares, a red star it is 1.73.

Knowing the color index the temperature of a star can be found by substituting it for I in the equation

So the temperature of Sirius is 11,200°, and that of Antares is 3,000°C.

color of the sky

Particles of matter too small to stop light waves or to reflect them, scatter them, that is send them in all directions.

Particles in the atmosphere of the earth, very fine dust or molecules of gas, scatter the blue light from the sun more than they do the longer waves of red. When we look up into the sky we see this scattered blue light.

The sun looks red at sunset because the light is coming through a thicker layer of air and more of the blue is scattered out. (*see* RAYLEIGH, SCATTERING.)

color of stars

Class O and *Class B* stars are blue-white, *Class A* stars are white, *Class G* stars are yellow, *Class K* stars are orange, and *Class M* are red. They differ in color mostly owing to the difference in their surface temperatures. The blue-white stars are the hottest (some have temperatures as high as 60,000°F), the red ones are relatively "cool" (between 3000 and 5000°F). Our sun is a yellow (*Class G*) star with a temperature of about 11,000°F. Very distant stars appear redder than they actually are because of the scattering of blue light by clouds of gas or dust in space.

color separation

All ordinary kinds of light, as sunlight or lamplight, contain various colors mingled together. Different colors are of different wave lengths.

Refraction of light, by lenses or prisms, bends each wave length by a different amount and so separates the colors.

This is why prisms are used, to form spectra. When a lens does the same thing, it is a *fault*. (*see* CHROMATIC ABERRATION.)

Columba [the Dove]

A southern constellation.

colure

An hour circle that passes through the celestial poles and the equinoxes (EQUINOCTIAL COLURE—q.v.) or the celestial poles and the solstices (SOLSTITIAL COLURE—q.v.).

coma

The nebulous haze that surrounds the *nucleus* of a comet.

Coma Berenices [Berenice's Hair]

A large cluster of faint stars a little behind the Great Bear.

It represents the hair of Berenice, queen of Egypt who sacrificed her beautiful hair to Venus on the return of the king from foreign wars

combustion

Burning or oxidation.

Usually restricted to the oxidation of carbon to form carbon dioxide, with sufficient rapidity to produce a flame.

comes (plural: comites)

The fainter member of a double star system

comet

A celestial body consisting of a *nucleus*, which is its most solid, condensed part and is surrounded by the nebulous, hazy light called the *coma* (the nucleus and the coma together are referred to as the *head*) and a *tail* that consists of a large, elongated cloud of gas which appears as the comet approaches PERIHELION (q.v.) and vanishes gradually as the distance of the comet from the sun increases once again (The tail usually points directly away from the sun) Most comets are members of the solar system and revolve about the sun in highly elongated elliptical orbits, they appear at regular intervals, and are therefore called *periodic comets* Other comets move around the sun in parabolic or hyperbolic orbits and sweep out into space never to return It is believed that a comet is a swarm of small, solid bodies, very similar to METEORITES (q.v.) held together loosely by their mutual attractions, and more concentrated near the center of the swarm.

When a comet is far from the sun it is cold and dark and therefore invisible. As it approaches the sun, it shines, partly by reflecting the sunlight, but partly in some other way. Gases and dust particles are driven off from the solid bodies in the head to form the coma and the tail. These may shine in the same way as the aurora.

TELESCOPIC COMETS (q.v.) usually have no tails. If they become bright enough to be seen with the naked eye they always do have one. The tail is very light and thin, consists of dust and gas driven off by the pressure of the sunlight.(*see* PRESSURE OF LIGHT.) The tail usually points away from the sun. After a comet passes the sun, it goes away tail first

About 40 of the well known comets have short, elliptical orbits, and revolve around the sun in 3 to 7 years. They belong to JUPITER'S FAMILY OF COMETS (q.v.) It is possible that these faint comets had originally longer orbits but were captured by the gravitation of Jupiter as they passed near it. (*see* CAPTURE THEORY.)

The spectrum of the light of a comet, especially that of the coma and the tail, is that of a glowing gas When it is close to the sun it shows the lines of sodium, iron and some other metals, and of several compounds of carbon. (*see* CYANOGEN IN COMETS).

In former times comets were feared as omens of disaster. They were supposed to be something within the earth's atmosphere.

After Tycho proved that a comet of 1577 was farther away than the moon, Derfel in 1680 showed that one was moving in a parabola, and Halley in 1682 worked out an orbit and predicted the return, comets then took their place as entirely respectable members of the solar system.

Bright comets usually appear without warning. The orbits of very few are known well enough so that their periods can be computed. The periods are very long, sometimes hundreds or thousands of years.

Some comets are so famous that they have been noted separately. Comets sometimes break into pieces as they pass the sun, and sometimes they disappear entirely.

Meteor showers often follow the same orbits as comets, and are supposed to be the remains of vanished comets. (*see* BIELA'S, HALLEY'S, DONATI'S, SCHWASSMANN-WACHMANN COMET, GREAT COMET OF 1882, COMET GROUPS.)

comet family

A group of short-period comets, the orbits of which show a peculiar relationship to the orbit of a given planet. (*see* JUPITER'S FAMILY OF COMETS.)

comet group

A number of comets which follow nearly the same path in the vicinity of the sun. (Cf. COMET FAMILY.)

The most remarkable group comprises the great comets of 1668, 1843, 1880, 1882 and 1887, all of which passed unusually close to the sun. They are probably parts of a single comet that divided on some previous approach but the separate parts acquired varying periods after the division.

comet seeker

A rather small telescope, usually 4 to 6 inches, with a wide-angle lens, so that it will show a large field, used to sweep the sky in a search for faint comets.

Amateur astronomers, with such instruments, often pick up comets before they are seen by professionals with larger instruments. This is because the professional is usually busy on some detailed investigation and has no time to be looking all over the sky.

cometography

That branch of astronomy which deals with the study and description of comets.

companion

In a DOUBLE STAR (q.v.), the less bright one of the two

components. (Cf. COMPANION OF SIRIUS, FAINT COMPANION STARS.)

companion of Sirius

In 1834 Bessel, a German astronomer, noticed that Sirius did not move regularly, but that its path among the stars was slightly wavy. He guessed that there was a small, invisible companion star whose gravity caused the waves. This star was first seen by Clark, an American, in 1862.

The companion is a white dwarf star, about 30,000 miles in diameter, (the size of Neptune) as far from Sirius as Uranus is from the Sun. Its period is 50 years. Its mass is nearly equal to the Sun's, but its luminosity is only 1/360 that of the Sun. Its density is about 30,000 times that of water. That means that a pint of this material would weigh about 20 tons.

It is believed to be made of atoms from which all electrons have been stripped so that they are packed much closer together.

comparison spectrum

A spectrum formed contiguously to one under observation and corresponding to it wavelength for wavelength.

In photographs of spectra it is usual to print above or below (or both) a narrow spectrum from a known source of light so that the position of the lines can be compared.

This comparison spectrum is usually photographed at the same time as the star spectrum by light from an electric arc attached to the side of the telescope. Often iron is vaporized in the arc, giving a spectrum with many definitely known lines.

compass

An instrument that provides a line or point of reference for determining directions or bearings. Compasses can be divided into two general types: MAGNETIC COMPASS and GYRO-COMPASS (q.v.).

compass error

The sum of the VARIATION and DEVIATION (q.v.).

compensation pendulum

A clock pendulum so constructed as to remain of the same length by automatic compensation of the effect of changes in temperature.

This is done by a jar of mercury, in the *Mercurial pendulum*, or by a system of rods of different metals, in the *gridiron pendulum*.

complement of an angle

The difference between 90° and the given angle—i.e., the angle that has to be added to the given angle to obtain 90°.

compression of a celestial body

The flattening of the body at the poles, i.e., its deviation from a perfectly spherical shape.

computation

Determining by calculation or counting (*see also* COMPUTED ALTITUDE.)

computed altitude

The angular distance of a celestial body above the RATIONAL HORIZON (q.v.) of an assumed position measured on the vertical angle through 90°. It is determined by computation.

Comstock refraction formula

All objects appear higher above the horizon than they actually are. The angular displacement (*r*), called refraction correction, must be added to observed zenith distance. Since refraction varies with barometric pressure (*b*) and temperature (*t*) of the atmosphere:

$$r(\text{seconds of arc}) = \frac{983\,b}{460 - t} \cdot \tan z$$

where t is degrees F., b is pressure in inches and z' observed zenith distance (*see* REFRACTION).

concentric

A designation applied to celestial bodies which revolve about a common center, or to orbits that describe circles around a common central point.

conduction

Transmission through a body called a conductor. Used in speaking of heat and electricity.

conformal projection

see LAMBERT CONFORMAL PROJECTION.

conic sections

The plane figures formed when a cone is cut by a plane, namely

Ellipse (eccentricity greater than 0, but less than 1) when the plane passes entirely through the cone so that the section is a closed curve If it passes at right angles to the axis, the eccentricity is 0 and the section is a circle

Parabola (eccentricity 1 when the cutting plane is parallel to a side of the cone The curve is not closed, and the two ends approach parallelism

Hyperbola (eccentricity greater than 1) when the plane cuts the base of the cone, but is not exactly parallel to the side, the curve is not closed and its ends are diverging

The orbits of some comets are supposed to be parabolic or hyperbolic, but this has never been proved

conjunction

Two celestial bodies are in conjunction when they have the same celestial longitude

The moon is in conjunction with the sun when it passes between the earth and the sun at new moon

Mercury and Venus show two conjunctions with the sun

Superior conjunction when they pass beyond the sun and change from morning star to evening star.

Inferior conjunction when they pass between the earth and the sun, and change from evening star to morning star.

The superior planets show only one conjunction when the sun apparently passes them, and they change from evening to morning stars.

conservation of areas, laws of

see LAW OF EQUAL AREAS.

conservation of energy

see LAW OF CONSERVATION OF ENERGY.

conservation of mass

see LAW OF CONSERVATION OF MASS.

conservation of moment

see LAW OF CONSERVATION OF MOMENT.

conservation of moment of momentum

see LAW OF CONSERVATION OF MOMENT OF MOMENTUM.

constant

A quantity the numerical value of which always remains the same (*see* PLATE II.)

constant of aberration

The apparent displacement of a star owing to the ABERRATION OF LIGHT (q.v.) when the earth is moving at average speed at right angles to the direction of the motion of the star; it is 20.5 seconds.

constant of gravitation

The force of attraction between two unit masses unit distance apart. It equals 6.670 × 10 in the centimeter-gram-second (CGS) system.

constellation

A grouping of stars, usually more or less conspicuous, together with the area of the celestial sphere covered by it. The ancients regarded the constellations as forming pictures of gods, heroes, animals, etc., and named them accordingly. Modern astronomers recognize 88 regions on the celestial sphere, bounded by parts of circles that are parallel and per-

pendicular to the celestial equator. They keep the names of the ancient figures.

The oldest account of the constellations that we know was written by Aratus, 270 B.C. They probably originated in the Euphrates valley, thousands of years before that time.

Ptolemy lists 48. The other 40 have been added mostly since 1600 A.D.

There were large gaps between some of the old constellation figures, and there were none near the south pole, in the part of the sky that was below the southern horizon. These spaces have been filled, so that now every star is in some constellation.

Seventy of the 88 are wholly or partly visible from the latitude of New York at some time during the year. (*see* ZODIACAL CONSTELLATIONS.)

constructive interference

see INTERFERENCE OF LIGHT.

continuous spectrum

A continuous band of colored light from violet to red. The source of light is a luminous solid or liquid. It may be a gas under special conditions.

The light is of all wavelengths, so that all colors are present in the spectrum.

contraction theory of the Sun's energy

In 1854, H. von Helmholtz developed the theory that the heat and the radiant energy of the sun are due to its contraction because of its cooling. The underlying theory is that as a body contracts it loses potential energy and gains an exactly equivalent amount of kinetic heat energy.

For about seventy years, scientists accepted this contraction theory as true and complete. Worked out in detail it meant that the earth had existed for only about 2.5 million years, and that not more than 10 million years in the future,

the sun would have become solid and too cold to support life on the earth.

This theory is no longer accepted It is replaced by the theory of atomic energy, which assumes that the matter in the sun is transformed into energy. (*see* SUN)

control rod

A rod of some element such as boron or cadmium, that is introduced into a nuclear reactor to control the chain reaction by absorbing neutrons

convection

Transmission of heat by moving heated gases

In a hot-air furnace the heated air rises and cooler, heavier air falls

convergent points of clusters

If lines are drawn representing the motion of stars in a moving cluster, their extensions will meet in a point This is the opposite of the radiant of a meteor shower

The convergent point of the 126 stars in the Ursa Major cluster is south of Capricornus The cluster is moving about 18 miles per second

The convergent point of the Taurus cluster is a little east of Betelgeuse in Orion There are about 265 stars in this cluster, about 130 light years away from the sun

conversion angle

The angular difference at any point between the rhumb line and the great circle between that and any other point.

coordinates

Lines drawn perpendicular to two other lines that are usually perpendicular to each other, and so fixing the position of a point.

Geographical coordinates The latitude and longitude of any place on the earth's surface

Celestial coordinates. The declination and right ascension of any celestial body. This is called the "equatorial system."

If the altitude and azimuth of the body are given, it is called the "horizon system."

If the celestial latitude and celestial longitude are given, it is called the "ecliptic system."

If the galactic latitude and longitude are given, it is called the "galactic system."

(*see* GALACTIC COORDINATES, HORIZON SYSTEM OF COORDINATES)

Summary of Four Systems

The four great circles on the celestial sphere, with which the positions of stars or other bodies may be located are: (1) celestial equator, (2) ecliptic, (3) horizon, (4) galactic equator or middle line of the Milky Way.

Distances from there, measured along arcs perpendicular to them, are called respectively (1) declination, (2) latitude, (3) altitude, (4) galactic latitude.

The poles of the four systems are (1) the celestial north and south poles, (2) the poles of the ecliptic, (3) zenith and nadir (4) galactic poles.

The zero points on the primary circles from which the east-west distance is measured are (1) and (2) vernal equinox, (3) south point on the horizon, (4) intersection of the galactic equator and the celestial equator.

The names and directions of east-west measurements are (1) right ascension, east 360° or 24 hours along the celestial equator, (2) longitude, to the east 360° along the ecliptic, (3) azimuth, to the west 360° along the horizon (4) galactic longitude, to the east, 360° along the galactic equator.

Copernican system

In 1543 Nicolaus Copernicus revived an old idea of the solar system in which he discarded the central, motionless earth for the central sun and the earth as one of the planets revolving about the sun in circular orbits.

This system was so revolutionary that it was a long time before it was widely accepted.

Copernicus could offer no proof of its truth. His only argument for it was its simplicity in explaining the celestial motions.

Coriolis effect

The deflection of a moving object owing to the rotation of the earth, to the right in the northern hemisphere, and to the left in the southern hemisphere. This phenomenon (also called *Coriolis acceleration*) must be considered when studying the motion of air masses over the earth, also in long-range ballistics and rocketry, as well as when using a bubble sextant (since the bubble is likewise deflected from its normal position, so that a correction to the left is necessary in the northern hemisphere, a correction to the right in the southern hemisphere).

Coriolis force

The deflecting influence of the earth's rotation which produces the CORIOLIS EFFECT (q.v.).

corona (of the Sun)

The pearly white crown of light that surrounds the darkened sun during a total eclipse.

It is the outer atmosphere of the sun, and extends to about one million miles above the surface. It is visible only during an eclipse but can now be photographed, at times with special equipment.

The shape of the corona varies with the sunspot cycle of 11 years. At sunspot maximum it is nearly circular, with streamers extending out in all directions. At sunspot minimum the streamers near the poles of the sun are short and often curved, like the lines of magnetic force, while those near the equator are unusually long and pointed.

The light of the corona is partly sunlight reflected from particles which are moving outward from the sun, probably

because of the radiation pressure of the sunlight; but mostly light emitted by the corona itself.

Its spectrum shows many bright lines in addition to the dark lines in sunlight. The bright lines were formerly attributed to an unknown substance that was called "coronium," but that idea has been abandoned, and they are thought to be due to well known elements in a peculiar state resulting from the condition of heat and pressure surrounding the sun.

Similar coronal lines have been seen in spectra of one variable star.

Corona Australis [the Southern Crown]

A southern constellation, below and left of Scorpius

Corona Borealis [the Northern Crown]

Between Hercules and Bootes there is a small semicircle of 7 faint stars. Represents the crown given to Ariadne by Bacchus at their marriage, after her death Bacchus threw it up into the sky, where it became fixed among the stars.

The Pawnee Indians called it 7 chiefs sitting around a council fire. Another Indian legend called it the Bear's Den where the big bear slept through the winter

A faint star, R Coronae Borealis, is one of the very small class of irregular variables. It sometimes changes very rapidly from 6th to 13th magnitude.

coronagraph

An instrument for observing the corona of the sun.

It is a telescope with special lenses and diaphragms to shut out the light from the disk of the sun. It usually has a spectrograph and a camera attached, for photographing the corona rather than for direct observation.

coronals

Streamers of luminous material which form in outer regions of the corona and move in toward the sun.

Sometimes called "coronal prominences."

coronavisor

An instrument for studying and photographing the corona of the sun, which makes use of television principles, and builds an image of the corona on a television tube.

coronium

An imaginary chemical element invented many years ago, to account for the bright lines seen in the spectrum of the corona of the sun. The idea has been abandoned.

The lines are now thought to be due to ordinary gases like oxygen or helium in some unusual condition due to the very low pressure, and possibly great heat, in this part of the sun's atmosphere.

A similar imaginary element, called NEBULIUM, was invented to explain similar lines in the spectra of some nebulae. It, too, has been given up.

Corporal

A medium range (75 miles) liquid-propellant surface-to-surface, guided ballistic rocket of the U.S. Army. Overall length 45 feet, body diameter 30 inches. Take-off weight about 12,000 lbs., thrust 20,000 lbs., velocity Mach 3.

corpuscular theory of light

The theory that light consists of streams of material particles hurled forth by the light source at high speed, which produce the sensation of light as they impinge on the retina of the observer's eye. This theory has been discarded in favor of the WAVE THEORY (q.v.), although the modern concept of the photon may be regarded as a return, to some extent, to the idea of particles.

Corvus [the Crow]

A small constellation of 6 third and fourth magnitude stars standing on the back of Hydra.

It represents the bird that Apollo sent to spy on Coronis, whom he loved. Because it brought an evil report, he changed

it from a white to a black bird, but put it among the stars in the sky.

The group of stars bears no resemblance to a bird, but looks more like the sail of a little ship.

There is nothing remarkable about any of its stars.

cosmic

Pertaining to or characteristic of the universe as a whole, or to celestial bodies (especially stars and galaxies) and their motions.

cosmic dust

Large clouds of obscuring DUST (q.v.) in interstellar space.

cosmic egg

The Belgian astronomer, Lemaitre has suggested that all the matter in the universe was once comprised in a relatively small volume which he calls the "cosmic egg" and after a long time the egg "hatched" with explosive violence, the fragments collected into stars and groups of stars

cosmic pile

The designation of an apparatus installed at a research station in the Alps, designed to record automatically the frequency of heavy showers of COSMIC RAYS (q.v.).

cosmic radio waves

Radio waves reaching the earth from space There seem to be at least two distinct types of this radiation: hydrogen line emission in a narrow frequency range (about 1420 mc/s), and a continuous emission covering practically all of the radio frequency range. (*see* RADIO SOURCES.)

cosmic rays

A radiation that bombards the earth constantly and is of extremely high penetrating power (able to go through 18 inches of solid lead, or 200 feet of water); it is stronger at the poles of the earth than at the equator. The *primary* cosmic rays (the radiation that arrives at the uppermost layer

of the atmospheric envelope of the earth) is generally assumed to consist of high-energy atomic nuclei that arrive from interstellar space; they collide with nuclei of atoms in the atmosphere and produce the *secondary* cosmic rays, which constitute practically all of the cosmic radiation detected and observed at the surface of the earth, since almost all the primary rays are stopped in the upper atmospheric layers.

cosmic repulsion

A hypothetical force, postulated to be independent of mass and increasing in strength with the increase of the distance between the interacting objects; it was introduced by Einstein at one time to allow the formulation of mathematical models of a static universe, but it was repudiated by him later.

cosmic static

K. G. Jansky's original term for the COSMIC RADIO WAVES (q.v.) discovered by him in 1932.

cosmic year

see YEAR

cosmical rising or setting

When a star or planet rises or sets at the same time as the sun does. (Cf. HELIACAL RISING OR SETTING.)

cosmogony

Any view, hypothesis or theory about the origin and development of the universe or any of its constituent parts or subdivisions. (see EXPANDING UNIVERSE, NEBULAR HYPOTHESIS, TIDAL THEORY.)

cosmology

That branch of theoretical astronomy which deals with the universe as a whole, embracing the study of the structure, dimensions and interrelations of the galaxies, nebulae, etc. Defined by G. Gamow as "the study of the general nature of the universe in space and in time."

Cosmos

All of creation.

co-tidal lines

Lines drawn on the surface of the ocean connecting those places which have their high water at the same moment of Greenwich time.

Coudé focus

Ar arrangement, used only on the largest reflecting telescopes, by which the focal length is greatly increased, and making it possible to have the spectrograph or the camera not attached to the telescope but in a separate room.

coulomb

A measure of electrical charge. It is the charge conveyed by a current of one ampere flowing for one second.

Council of Nicea

In the year 325 A.D. a great council of the Christian Church was held at Nice. Among other things it decided how to find the date of Easter, and that for this purpose it should be considered that the Vernal Equinox always falls on March 21, as it did that year.

Their rule was, and is, "Easter shall be the Sunday following the first full moon that occurs on or after the 21st of March," though special rules are used to determine which full moon is actually to be used.

count

In radiation measurement, the individual response of the counting device to an ionizing event. Also the indication of the total of the events registered during a certain period or interval of time.

countdown

(ASTRONAUTICS) The practice of counting off the minutes and seconds remaining before launching a rocket.

counter

see RADIATION COUNTER.

counterglow

see GEGENSCHEIN.

countersun

A rarely seen kind of HALO (*q.v.*), which appears as a luminous white spot opposite the sun, at the same altitude above the horizon as the sun. (Also called *anthelion.*)

course

In navigation and nautical astronomy, the course of a ship is the direction in which a ship is intended to sail, i.e., the direction prescribed for the ship's movement or progress. It is measured and expressed in degrees from 0° at north, clockwise to 360°. (Cf. HEADING.)

Crab Nebula

A nebula in our galaxy, situated about one degree northwest of α Tauri believed to be the remnant of the supernova observed in 1054 A.D. It is one of the most powerful RADIO SOURCES (*q.v.*) known.

Crater [the Cup]

A small constellation just west of Corvus and standing on the back of Hydra.

The Greeks called it the Cup of Apollo. They say Apollo sent the Crow to get a cup of water. He stopped at a fig tree waiting for the fruit to ripen, returned with the cup empty and a snake in his beak, and claimed the snake had made him late. Apollo put all three in the sky together.

There are no stars of special interest in this constellation. (*see* CORVUS and HYDRA.)

craters of the moon

The most characteristic feature of the moon's surface (*see* MOON).

There are more than 30,000 on our side of the moon. They

vary in size from tiny pits that are just visible, about 1000 feet across, to great walled plains, the largest nearly 150 miles in diameter.

They are nearly circular. Their walls are very steep, often terraced on the inside, sometimes with peaks as high as 20,000 feet. Many have lower peaks near their centers. In some cases the floor of the crater is several thousand feet below the surrounding plain. In other cases it is higher, in one case filled almost to the top of the wall. Some craters have rough, bright floors, others are smooth and dark.

Crepe Ring of Saturn

The ring nearest to the planet, the faintest of the three and the one that revolves fastest.

It was discovered by Bond of Harvard in 1850. It is 11,500 miles wide, is separated from the bright ring by a division 1000 miles across, and its inner edge is 7000 miles from the surface of the planet. Its light is much fainter than that of the other two rings, and one of the bright moons has been seen through it.

The little, solid particles that compose the ring revolve around the planet so rapidly that they would rise in the west and set in the east, like the inner moon of Mars.

crepusculum

Twilight or dusk.

crescent moon

The shape in which less than half of the face of the moon is illuminated by the sun which is shining principally on the side of the moon away from the earth. This phase can be observed between the NEW MOON and the FIRST QUARTER, and between the THIRD or the LAST QUARTER and the NEW MOON (qq.v.).

The OLD MOON CRESCENT can be seen in the eastern sky before sunrise, and sometimes in the daylight. The NEW MOON

CRESCENT appears in the western sky before sunset or in the evening (*see* PHASES).

The planets Mercury and Venus show the crescent phases, but no other planet can.

A spherical artificial satellite painted for diffuse reflection, would also demonstrate moonlike phases.

criterion for double stars

see AITKEN'S CRITERION FOR DOUBLE STARS

critical mass

That amount of fissionable material that is just enough to sustain a chain reaction.

cross motion

The TANGENTIAL VELOCITY (*q.v.*).

Crux [the Southern Cross]

A southern constellation.

culmination

The time at which a star, or other celestial body, crosses the observer's meridian above the horizon, a synonym for UPPER TRANSIT.

All circumpolar stars will have two culminations, the upper, where it is above the celestial pole, and the lower, when it is below the pole. They occur where the star is at its maximum and minimum meridian altitudes (*see* MIDNIGHT CULMINATION).

curie

A unit of radioactivity, equal to 37 billion disintegrations per second, it is the amount of radioactivity associated with 1 gram of radium. One curie equals 1000 millicuries (*mc*) or 1,000,000 microcuries (μc).

curve of growth

A diagram showing the relation between the width of a

spectral line and the number of absorbing atoms per square centimeter.

cusp

The pointed end of a crescent. The cusps of the crescent moon always point away from the sun, and a line joining them is nearly perpendicular to the ecliptic in the vicinity of the moon. (Mercury and Venus are the only two planets that likewise appear in crescent stage, and their cusps also point always away from the sun.)

cyanogen in comets

This gas, which is poisonous to breathe, has been found in the spectra of some comets.

When the comet is far from the sun its principal radiation comes from cyanogen. As the comet approaches the sun, the light of methane, CH_4, carbon monoxide, CO, carbon, C, and nitrogen, N_2 appear.

Some people have thought that if the earth should pass through the tail of a comet, as it certainly did in 1861 and probably did in 1910, all life would be wiped out by these poisonous gases. But since every molecule is several miles from its nearest companion, the gas is too thin to do any possible harm.

cycle

A length of time during which a set or series of phenomena occur, at the conclusion of which conditions are usually approximately the same as they were at the beginning; the phenomena constituting the cycle are usually recurrent and re-occur in the same order or sequence.

cyclic

Recurring at definitive periods or intervals.

cyclic motion

Rotational motion in which the velocity is not uniform but varies in definite cycles.

Cyclones

Whirling storms or systems of winds, often violent in the tropics but moderate elsewhere. The wind velocity becomes as much as 90-130 miles per hour, and the storm moves 20-30 miles per hour. The direction of the whirl is clockwise in the southern hemisphere, and counterclockwise in the northern.

Similar storms occur on the sun, make holes in the cloudy photosphere and cause the sunspots.

Cygnus [the Swan]

A beautiful constellation, in the Milky Way close to Vega. Better known as the *Northern Cross*

It represents the boy Cygnus, friend of Phaeton, who tried to drive the chariot of the sun, let the horses run away and was hurled by Jupiter into the river Eridanus where he drowned Cygnus searched for his body until the gods changed him into a swan so that he might live forever on the river.

Deneb, at the top of the cross is a giant or supergiant star, but 460 light years away

Near the cross are the North America and the Veil nebulae, and also the northern Coal Sack

Albireo, at the foot of the cross, is a beautiful double even with a small telescope One star is blue and the other yellow.

D

daily aberration

The apparent displacement of a star in the course of a day, owing to the rotation of the earth about its axis; the ABERRATION OF LIGHT (q.v.) causes the star to appear to trace a very small circle in the sky every day, but owing to the tremendous difference between the velocity of light and the speed of the earth's rotation, this displacement is negligible except for the most precise calculations (its maximum magnitude is 0.3 of one second).

Dalton's law

The law that states in a mixture of two or more gases the total pressure equals the sum of the pressures that each gas would exert if it were present alone.

dark eclipsing variables

Binary star systems (q.v.) consisting of a fairly bright star and an almost dark companion, which revolve around each other, and if the plane of their orbits is in our line of sight, the dark companion eclipses the brighter *primary* once during each revolution. Their periods are perfectly constant. The best known member of this group is Algol (β Persei).

dark filament

In spectroheliography, a QUIESCENT PROMINENCE (q.v.) seen as a long, dark streak.

dark-line spectrum

A spectrum that consists of an array of dark lines against

a bright background, or which contains some lines that are darker than others. It may be described also as a continuous spectrum crossed by many dark lines. Cooler gas intervenes between the source of the continuous spectrum and the observer; this cool gas is opaque to precisely the wavelength which it would emit if heated to incandescence. Thus the pattern of dark lines is characteristic of the chemical elements of which the gas is composed. It is the reverse of a BRIGHT-LINE SPECTRUM (q.v.), and is referred to also as *reversal* or *absorption spectrum*.

dark nebula

The numerous dark patches in the Milky Way, and near some bright, diffuse nebulae, are now called dark or obscure nebulae and believed to be clouds of dust, possibly specks of iron, zinc or copper. These great clouds hide the stars that are beyond.

The most conspicuous of them are:

The Southern Coalsack near the Southern Cross. It is a dense cloud of dust about 300 light years away from the sun.

The Horse head Nebula in Orion This is the darkest part of a very large cloud that covers nearly half of the constellation.

The Gulf of Mexico near the North America nebula in Cygnus.

(see ABSORPTION OF STARLIGHT.)

darkening at the limb

Direct observation or photographs of the sun show that the edge of disk is not nearly so bright as the center.

This is due to absorption of light by the sun's atmosphere. Light from the limb must pass through a much thicker layer of atmosphere than light from the center.

The same effect is observed on the planets Jupiter and Saturn. These large planets have extensive gaseous atmospheres.

Dart

A short-range (5 miles) solid-propellant powered surface-to-surface missile of the U. S. Army. Overall length about 6 feet, body diameter less than 1 foot; velocity 650 m.p.h.

date line

see INTERNATIONAL DATE LINE.

daughter, daughter element

In nuclear physics, the product nucleus or atom that results from the decay of another element (called the *precursor* or *parent* element).

dawn rocket

A rocket launched at dawn, i.e., from the DAWN SIDE (q.v.) of earth; the take-off velocity of the rocket is increased in this case by the orbital velocity of the earth (18.5 miles per second).

dawn side

That side of a planet or other celestial body which points in the direction of its orbital movement.

day

The obvious and most natural division of time. For most people it is the interval between midnight and midnight.

The Chinese, ancient Greeks and Jews began it at sunset. Babylonians, Syrians, Persians and modern Greeks began it at sunrise. Arabs and some astronomers count from noon to noon.

There are different kinds of days:

Sidereal day. The interval between two successive upper transits of the vernal equinox. This, like sidereal time, is gotten from the stars. It measures one rotation of the earth.

Solar day. The interval between two successive lower transits of the sun. That is midnight to midnight. It is nearly 4 minutes longer than a sidereal day.

Astronomical day. Until a few years ago astronomers began

the day at noon instead of midnight, so that they would not have to change the date in the middle of a night of observing the stars. They counted the hours from 1 to 24 instead of two series of twelve. This is very little used now.

Star day The interval between two successive passings of the same star across the meridian

Civil day A day of mean solar time counted from midnight to midnight in two series of hours from 1 to 12

Calendar day One of the days of the month as fixed by the Gregorian calendar

Julian day For certain astronomical work it is more convenient to use a simple day-count instead of the calendar.

The Julian Era began with the 1st of January 4713 B.C. and the Julian day is the number of the days since that time The day begins at noon

January 1 1958 is Julian Day 2 436 205

Lunar day The interval between two successive crossings of the meridian by the moon

It is 24 hrs 50 min long

dayglow

see AIRGLOW

daylight saving time

Local mean time of a meridian 15° east of the normal zone or standard meridian Daylight saving time is normally one hour later than zone or standard time for that community It is usually used only during summer months in order to effect economies and to offer additional daylight hours, and local option and decision by competent authority stipulates whether or not a given community shall adopt this time temporarily During war years a similar time was almost universally adopted, and was known as War Time. In some cases both war and daylight saving time were observed making a two hour differential between local and standard time

daytime (meteor) shower

The encounter of the earth with a *meteor swarm* that ap-

proaches it from the sunward direction and therefore produces a METEOR SHOWER (q.v.) not visible at night.

Deacon

A solid-propellant rocket, 16 feet long, with a body diameter of 8 inches, weighing about 200 lbs.; equipped with a booster rocket, for high-altitude research.

dead reckoning

The method of determining position by applying to the last fix the courses steered and distance made good as best deduced from instrument readings at hand, without verification from astronomical sights or radio or other bearings. Also referred to as *deduced reckoning*.

decay

In nuclear physics, the spontaneous nuclear process that may result in the emission of alpha, beta or gamma radiation, etc. (Synonymous with *disintegration.*)

deceleration

Loss of velocity of a moving body; also the rate of such loss of velocity.

declination

The angular distance of a celestial body from the celestial equator along the hour circle to the body. Measured in degrees, minutes and seconds, through 90°, and named north or south as the body is north or south of the celestial equator. Declination is analogous to the latitude on earth. (Cf. POLAR DISTANCE.)

declination, magnetic or compass

Angle of deflection of a magnetic compass from true north. Same as *compass variation.*

declination axis

In a telescope, the axis passing through the center of the DECLINATION CIRCLE (q.v.) around which the telescope moves to get the stars in the field.

declination circle of a telescope

A graduated circle fixed to the mounting of the telescope by which the instrument can be pointed to a star whose declination is known.

The HOUR CIRCLE must also be used. (q.v.)

deduced reckoning

see DEAD RECKONING.

deep space

(ASTRONAUTICS) A colloquial term for space beyond the outermost boundaries of our solar system.

deferent

In the Ptolemaic system the large circular orbit, with the fixed earth at its center along which a FICTITIOUS PLANET revolved and which was the center of a small circular EPICYCLE (q.v.) on which the real planet revolved.

deflection of starlight

Einstein's theory of relativity stipulates that a ray of light passing close by a massive body like the sun must be deflected as if the body could attract the ray and draw it from its straight course. This would make two stars, on opposite sides of the sun appear to be farther apart than they really are by 3.5 seconds.

This can be checked only at the time of a total eclipse of the sun, by photographing the stars and comparing with other photographs of the same stars, taken at a different time.

Such tests have been made and they seem to prove that the theory is true.

degenerate matter

The extremely dense form of matter consisting of atomic nuclei stripped of their orbital electrons and packed densely together, and therefore no longer possessing the chemical properties of ordinary substances. It can exist only in white dwarf stars, the tremendous gravitational forces of which

provide the vast pressures which are the prerequisites of its existence.

degree

1/360 part of a circle. It is used for measuring arcs or angles.

For latitude and longitude it is 1/360 part of a great circle of the earth.

One degree of longitude is 69.65 miles at the equator, and 53.43 miles at latitude 40°.

Deimos

The outer and smaller of the two moons of Mars.

It is 7½ miles in diameter, and 14,600 miles from the center of the planet, or 12,493 miles from its surface. It revolves in 30 hours 18 minutes, which is only six hours longer than a day on Mars.

The two moons were discovered by Hall, in Washington in 1877.

Because its orbital motion eastward is so nearly equal to its daily motion westward, it is nearly 132 hours, more than 5 days, between two successive risings. During the 66 hours between its rising and setting it goes through all of its phases twice. It gives very little light, only 1/1200 as much as our moon. (*see also* SATELLITES OF THE SOLAR SYSTEM.)

Delphinus [the Dolphin]

An interesting, little constellation close to Aquila. It contains 4 faint stars that form a diamond often called JOB'S COFFIN.

It is the dolphin that saved the life of the musician Arion, when he jumped off the ship on which the sailors meant to kill him to steal his money.

It is one of the smallest of the constellations, containing only 2 third and 4 fourth magnitude stars. The star Gamma is a beautiful double, whose stars are golden yellow and bluish green.

Delta Cephei

The variable star in Cepheus, for which the CEPHEID VARIABLES (q.v.) were named.

It was discovered by two English astronomers in 1784. The first known of the pulsating stars, it varies between magnitudes 3.6 and 4.3 in a period of 5 days and 9 hours.

The rise in brightness is rapid, only 1/3 of the total period. The decline is smooth and much slower.

It is a large star 30 times the diameter of the sun. Its spectrum varies, from *F0* at maximum to G2 at minimum.

The star is believed to expand and contract, or pulsate, under the influence of gravity and temperature.

Deneb

The traditional name of the star α Cygni (*see* STARS—*Plate X*).

density

The amount of matter in a unit volume of a substance. It is usually defined as the mass of a body divided by its volume. The density of water is taken as the basis of comparison. For instance, the density of the earth is 5.52 times that of water, which means that it is 5½ times as heavy as a ball of water of the same size.

The density of the sun is 1.41, that of the moon, 3.33. That of Saturn is only .71 which means that the planet would float in water.

The densities of the stars vary greatly. That of Antares is only 1/2000 of the density of ordinary air while that of the companion of Sirius is 30,000 times that of water.

departure

The distance due east or west that a ship sails on its course. It is also the length of a parallel included between two meridians, expressed in nautical miles; it varies with the latitude. (The angular measure of the same arc is the *difference in longitude*.)

depression

Negative attitude; the angular distance of a celestial body below the horizon.

descending node

The intersection of the ECLIPTIC (q.v.) and the orbit of a heavenly body which that heavenly body passes on its way from the north to the south of the ecliptic. (Cf. NODES OF THE MOON'S ORBIT.)

descriptive astronomy

That branch of ASTRONOMY (q.v.) which deals with the enumeration and description of celestial bodies, but without being concerned with physical or mathematical theories.

destructive interference

see INTERFERENCE OF LIGHT.

deviation

Error in a magnetic compass caused by the magnetism of the ship or aircraft. It is the angle between the MAGNETIC MERIDIAN (q.v.) and the axis of the compass card when the latter is deflected from the magnetic meridian by the magnetism of the ship or aircraft. If the north point (0°) lies eastward of the magnetic north, the deviation is marked *east* or (+), otherwise it is marked *west* or (—).

deviation of falling bodies

If a ball is dropped from a tower 328 feet high, it will strike the earth .62 of an inch east of the perpendicular.

This is due to the rotation of the earth. The top of the tower rotating in a larger circle than the base, gives the ball a greater eastward velocity.

diameter

The distance from one side of a body to the other, measured through the center.

The *linear diameter* is measured in linear units, inches, feet or miles.

The *apparent* or *angular diameter* (q.v.) is measured in angular units; degrees, minutes and seconds.

When the angular diameter and the distance of a body are known it is easy to calculate the linear diameter.

diameter of stars

The stars are all so far away that no telescope in existence can show them as disks. They appear only as points of light.

However the diameter of a few have been measured with the INTERFEROMETER (q.v.) or calculated from the total luminosity and absolute magnitude.

The smallest white dwarf star has a diameter about four times that of the earth. That of the companion of Sirius is about 30,000 miles, the size of Neptune.

Many stars are about the same size as the sun. The diameter of a few [illegible] of the sun's diameter are α Centauri 1.3, Altair 1.6, Sirius 1.9, Procyon 2.3, Vega 2.6.

Giant stars are vastly larger. Some of the largest are, in terms of the sun's diameter: Arcturus 27, Aldebaran 38, Antares 290 to 390, α Herculis 400, Betelgeuse 300 to 400, Mira 500.

difference of altitude

see ALTITUDE DIFFERENCE

difference of latitude

The angular distance between the parallels of any two points. For places on the same side of the equator it equals the numerical difference of their latitudes. For places on opposite sides it equals their numerical sum.

difference of longitude

The angular length of the shorter arc of the equator and the intersections of meridians passing through any two points. If both are in the same longitude system the difference represents the numerical difference between their longitudes. If one is east and one is west, the difference of longitude equals th

In general, the phenomena produced hen a radiation is

numerical sum of their longitudes, unless the sum is greater than 180°, in which case the difference of longitude equals 360° minus the sum.

differential method

Finding the position of a star, by measuring the difference of right ascension and declination between it and some neighboring star, whose place is given in a star catalogue.

Finding the parallax of a star, by measuring the change of position of the star, with reference to other faint stars, which are in the same telescopic field of view, but so far away as to have no sensible parallax of their own.

diffraction

interrupted or obstructed by an opaque obstacle or obstacles. With reference specifically to light, the spreading of the light as it passes the edge of an opaque body, when the light waves bend slightly around the edge of that body, as it were, so that the body does not cast a definite shadow: several alternately light and dark bands, called *diffraction fringes*, are seen at the edge of the shadow, parallel to it.

diffraction grating

A system of close, parallel lines ruled on a polished metallic surface. It is used in a spectroscope, instead of a prism, to form a spectrum. Spectra made with a grating of several thousand lines to the inch are much larger than those made with prisms. If the grating is made by ruling lines on a transparent substance, and the spectrum formed by light passing through the grating, it is called a transmission grating.

diffraction ring

Concentric ring, one or more of which surround the small disk-shaped image of a star formed in a telescope. These rings are more noticeable in small telescopes than in large ones.

diffuse nebula

An irregular, shapeless, often very large NEBULA (q.v.) that may be either bright or dark. The bright ones may be so

bright that they appear solid, or so faint and filmy that stars can be seen through them. Diffuse nebulae are clouds of gas or dust. Their spectra often show bright lines, indicating that they are glowing gas, probably glowing by fluorescence caused by the ultraviolet light from stars that are in or near the cloud, in that this ultraviolet radiation ionizes atoms of the gas, which emit light of wave lengths that are visible to us. Their light is feeble, and usually a long time exposure is needed to make it register on the photographic plate sufficiently to produce a picture. According to Hubble's classification, diffuse nebulae are subdivided into three classes: (*a*) predominantly luminous, (*b*) predominantly obscure, (*c*) conspicuously mixed.

digit

One twelfth part of the diameter of the sun or the moon.

It was formerly used to express the quantity of an eclipse, but is very seldom used now.

Dione

A satellite of Saturn. (*see* SATELLITES OF THE SOLAR SYSTEM.)

dip of the horizon

In measuring the altitude of stars at sea the visible horizon is below the true astronomical horizon because of the curvature of the earth, and the height of the observer above its surface. This difference is called the dip. It is measured in minutes of arc, and is equal to the square root of the height of the observer above sea level in feet.

direct motion

The apparent motion of a planet among the stars eastward, in the same direction as the planet's motion around the sun. It is the motion which a planet has when its RIGHT ASCENSION (q.v.) is increasing.

The apparent motion of the superior planets is direct for most of the time. Once each year it becomes retrograde for awhile. (*see* RETROGRADE MOTION.)

direct tides

The tides formed on the side of the earth nearest the sun or the moon. (*see* TIDES.)

direct vision spectroscope

A SPECTROSCOPE (q.v.) that employs a train of prisms so arranged as to make the collimator, prism and view telescope lie along the axis of a single tube housing the entire system. A diffrac ion grating may also be used.

direction

The direction of a line that passes through a point on the earth is the angle between the line and the meridian of the place, measured clockwise from 0° at north to 360°. In nautical astronomy, *true direction* is an expression of direction measured from true north, *magnetic direction* is an expression of direction measured from magnetic north, and *compass direction* is an expression of direction measured from the north point of the compass card.

directional aerial

In radio astronomy, an aerial that has the property of receiving or radiating radio waves in certain directions more effectively than in others.

directions in the sky

Directions are measured from the celestial equator which is always directly overhead at the earth's equator.

North and south are perpendicular to this equator.

East and west are parallel to the equator and toward the sunrise and sunset respectively.

discrete radio source

A small area source of emission in the radio wavelengths; many of these sources are believed to be beyond the range of optical telescopes, and most of them seem to be outside

our galaxy. They have been variously explained as produced by normal galaxies, by supernovae and by collisions of galaxies. Formerly these sources were called *radio stars.*

dish

In radio astronomy, a colloquial term for a parabolic antenna.

disintegration

A nuclear transformation resulting in a loss of mass and in the emission of energy in the form of radiation; particles are emitted by the nucleus, or else it splits into two or more pieces.

disk

The seemingly flat figure of a celestial body, sun, moon or planet, as it appears in the sky. It may be circular, gibbous or crescent.

dispersion of light

When a ray of white light passes obliquely into another medium, as from air into glass, it is dispersed, or separated into the colors of the spectrum. Because the amount of refraction increases as the wavelength decreases, the change in direction is greater for violet than for red light.

Lenses and prisms disperse light at the same time as they refract it.

So do fine gratings. (*see* DIFFRACTION.)

The particles of air disperse the sunlight which is why the sky is blue. (*see* SCATTERING.)

display

In *telemetry*, an occasionally used synonym for RECORDER (q.v.).

dissipation of energy

Since the sun and the stars are constantly giving off energy

in the forms of heat and light, and since this energy goes to warm the cooler bodies, like the planets, and can never be returned to its sources, it follows that there must come a time, in the far distant future, when the sun and the stars will cease to shine.

No one can set a limit to the time that the stars will endure. It will certainly be many thousands of millions of years, but there must be an end when everything has become cold.

distance between stars

A convenient way of measuring their difference in direction.

Apparent distance: how far apart they seem to be on the sky or on a map or chart.

Angular distance is their difference in direction measured in degrees.

For rough measurements, the apparent diameter of the sun or moon equals half a degree.

The pointers of the Big Dipper are 5° apart. The two stars in the top of the Bowl of the Big Dipper are 10° apart. The Belt of Orion is 3° long.

distance-luminosity relation

The intensity of the light of a star is inversely proportional to the square of its distance.

distance modulus

see MODULUS OF DISTANCE.

distance of the components of a binary star

The angular separation between the two component stars.

disturbing forces

A collective term for the factors which produce PERTURBATIONS (q.v.) in the orbit of a celestial body.

diurnal aberration

see DAILY ABERRATION.

diurnal circles

The apparent daily paths of all celestial bodies around the sky. They are all parallel and are described in the same time.

diurnal motion

The apparent daily rotation of the heavens from east to west, it is an effect of the earth's rotation about its axis.

diurnal parallax

see PARALLAX

dog days

A period of nearly six weeks, between early July and late August, when Sirius, the Dog Star, rises at almost the same time as the sun.

The dates are not fixed because the heliacal rising of Sirius varies in different latitudes.

The old idea was that Sirius and the sun together brought the season of greatest heat, and the time while dogs were most likely to go mad.

Dog Star

see SIRIUS

Donati's Comet

One of the greatest comets seen during the 19th century, which was visible to the naked eye for 112 days in 18[illegible]. With telescopes it was watched for more than 9 months.

Its tail was 50 million miles long, curved and very wide at the end, and split into two or three streamers.

The head of the comet passed across the star Arcturus, which was easily seen through the comet.

Its orbit reaches about 10 times the distance of Neptune, and its period is about 2000 years.

Doppler effect

The apparent change of the wavelength of any electro-

magnetic radiation or wave motion in general when the distance between the source of the radiation and the observer is increasing or decreasing owing to the motion of either or both. In the domain of spectroscopy and spectrography, when a source of light is relatively approaching the earth, the lines in its spectrum are shifted toward the violet; if the source is receding, the spectral lines are shifted toward the red. The amount of the shift in either case is proportional to the velocity of approach or recession. This phenomenon enables astronomers to measure the motion of stars in the line of sight, to study the rotation of the sun and the planets; it furnished the first evidence of the constitution of the Rings of Saturn, of the existence of spectroscopic binary stars.

Doppler-Fizeau principle

The basic principle that underlies the *Doppler effect* as applied by Fizeau to spectral lines and their shifts.

Doppler radio

An apparatus that utilizes the *Doppler shift* manifested in the shift in the frequency of radio waves for tracking missiles and rockets in flight.

Dorado [**the Swordfish**]

A southern constellation.

dosage

see DOSE.

dose

In radiation physics, the amount of energy absorbed in a unit volume or an organ or individual. Also called *dosage.*

dose rate

In radiation physics, the DOSE (q.v.) delivered in unit time.

dosimeter

An instrument measuring radiation dosage.

double star

Two stars that appear as a single star to the naked eye, but as a pair when seen through a telescope. A pair of stars that are seen as one star by the naked eye solely because they are nearly in a straight line to the eye of the observer is called an *optical* (or *accidental*) *double star*; a pair of stars that are actually close to each other and united by the bond of their mutual gravitation is called a *physical double.* (*see* AITKEN'S CRITERION FOR DOUBLE STARS, BINARY STAR.)

double star collision hypothesis

Lyttleton's hypothesis of the origin of the solar system, which differs from the COLLISION HYPOTHESIS (q.v.) of Jeffreys chiefly in that it postulates that the sun originally was a double star, and a star that passed by collided with one companion of the binary system.

doublet

A lens made of two different kinds of glass, so shaped that it is free from chromatic and spherical aberration, coma, astigmatism and curvature of the field.

Such lenses are used in the best telescopes and cameras.

Draco [the Dragon]

A long snake-like constellation that half surrounds the Little Dipper in the north. It contains no star brighter than 3rd magnitude.

It is a very ancient figure, perhaps going back to the Babylonian story of Bel and the Dragon.

The Greeks said it was the dragon that Juno put in the Garden of the Hesperides to guard the tree with the golden apples. It was killed by Hercules, and among the stars Hercules has his foot on the dragon's head.

Alpha Draconis, called Thuban, a 3d magnitude star in the dragon's tail, was pole star 4,700 years ago when the Great

Pyramid was built in Egypt, and shone down its central passage in the year 2170 B.C.

Draconids

The designation of several slow-moving meteor showers the radiants of which lie in the constellation Draco, and called according to the location of the radiant, ι Draconids, γ Draconids, ο *Dracondis*, and ζ *Draconids* (they reach their maxima, respectively, on June 28, June 25, August 22, August 22).

Draconitic month

see NODICAL MONTH.

Draper catalogue

Nine volumes, completed in 1924, giving the positions, magnitudes, and spectral classes of 225,300 stars. Extensions have been published since.

This is one of the largest catalogues ever made. It was compiled at Harvard, and published as a memorial to Henry Draper who was the first American astronomer to study stellar spectra.

Draper classification

The separation of nearly all stars into ten classes according to their spectra. (*see* CLASSES OF STARS.)

This was done by Miss Cannon of Harvard, but was named for Draper as a further tribute to his work on spectra.

drift angle

In aerial navigation, the angle between the *track* (the direction of travel of the aircraft over the ground) and the *heading* (the direction in which the aircraft is pointed).

drift of stars

see STAR DRIFT.

driving clock

A CLOCK (q.v.) used to turn a telescope just as fast as the stars appear to move across the sky, so as to keep one star in the field of view for a long time.

Electric motors are now commonly used instead of clocks for this purpose.

Dubhe

The traditional name of the star α Ursae Majoris, one of the "Pointers" of the Big Dipper.

dusk rocket

A rocket launched at dusk, i.e., from the DUSK SIDE (q.v.) of earth; the take-off velocity of the rocket is diminished in this case by the orbital velocity of the earth (18.5 miles per second). (*see* DAWN ROCKET.)

dusk side

That side of a planet or other celestial body which points away from the direction of its orbital movement.

dust

Fine particles of matter.

The nebulosity around the stars of the Pleiades is supposed to be clouds of dust that shine by reflected light. (Cf. COSMIC DUST.)

dwarf sequence

The MAIN SEQUENCE of stars (q.v.).

dwarf stars

Some stars are very small, only the size of the earth or one of the other planets. They are often the part of a double or multiple star. Some of them have surprising densities.

One called Omicron Eridani B is only six millionths the volume of the sun but is nearly one half as heavy. One cubic inch of its material weighs two tons.

Another, Van Maanen's Star, is about three ten-millionths the volume of the sun but would weigh seven tons per cubic inch. (*see also* COMPANION OF SIRIUS.)

dynamic encounter, hypotheses of

The PLANETESIMAL HYPOTHESIS and the TIDAL THEORY (q.v.) of the origin of the solar system.

dynamical parallax

Parallax of binary stars computed from the sum of the masses of the components of the binary system.

see PARALLAX.

dyne

A unit of force.

The force that would give a body with a mass of one gram, an acceleration of one centimeter per second.

E

E layer

see HEAVISIDE LAYER.

EO, El, etc.

see ELLIPTICAL GALAXY.

Earth

The third planet out from the sun. Mean distance 92,870.000 miles.

Equatorial diameter 7,927 miles. Polar diameter 7,900 miles. Difference 27 miles.

Period of revolution 365.256 days.

Period of rotation 23 hours 56 minutes.

Mass $6.6 \times 10^{[illegible]}$, i.e. 6 sextillion tons.

Density 5.52 times the density of water. The orbit is more nearly a circle than that of the other planets except Venus and Neptune. The earth is about 3,000,000 miles nearer the sun in January than in July.

The atmosphere is about 500 miles deep, and is made of nitrogen, oxygen, water vapor, and other gases.

earthlight

The earth shines by reflecting sunlight, just as the moon and other planets do. Earthlight is bluer than direct sunlight, because much of it is reflected from the air and the blue of the sky predominates in the reflected light.

Earthlight is reflected from the moon during the crescent

phases, and lets us see the "Old moon in the new moon's arms."

The earth is full when the moon is new. Full earthlight is about 40 times as bright as full moon light, because the earth is larger than the moon, and also a better reflector.

earth-moon system

Our moon is larger and more massive in comparison with the earth than any other satellite with respect to its planet. On this account it and the earth have many characteristics of a double planet.

Viewed from Venus, the earth would appear brighter than Venus ever does to us while the moon would be as bright as Jupiter and about ½°, the apparent diameter of the moon, away from the earth.

As the earth and moon revolve about the sun, the orbit of the moon is always concave toward the sun.

The center of mass of the system is 2900 miles from the center of the earth and so within the earth.

earth motions

The earth has 5 principal motions.

1. *Rotation.* The earth turns on its axis once a day. The motion is eastward, and the speed varies with the latitude. A point on the equator moves more than 1000 miles an hour. At the poles it is zero.

2. *Revolution.* The earth revolves eastward around the sun once in a year. The average speed is 18½ miles a second, or 66,600 miles an hour.

3. *Precession.* The earth's axis wobbles like a spinning top, westward around a line joining the poles of the ecliptic. One wobble takes about 25 800 years.

4. *Solar motion.* The sun, carrying the whole solar system with it, is moving, relative to the neighboring stars, nearly in the direction of the star Vega, at the rate of 12 miles a second, or 43,200 miles an hour.

5. *Galactic motion.* The sun, and all the planets with it,

is revolving around the center of our galaxy, once in about 200,000,000 years, at the rate of 175 miles a second or 620,000 miles an hour

earthshine

The sunlight reflected from the earth's surface onto the moon and back into the eyes of an observer on the earth, enabling him to see that part of the moon not illuminated directly by the sun, as a faintly visible area against the sky.

earth tides

Tides in the solid body of the earth (*see* TIDES.)

east

The direction of sunrise

The point on the horizon where the sun rises at the equinoxes

east point

The east of the horizon is that intersection of the PRIME VERTICAL (q.v.) with the horizon which lies to the right of the observer facing north

Easter

SEE COUNCIL OF NICEA

ebb current

Horizontal motion of water away from the land as tide is falling (*see* TIDES.)

eccentricity

The degree of the flattening of an ellipse, i.e. its deviation from a circular shape. With reference to the orbit of a celestial body, the distance between the center of its orbit and the center of the primary about which it revolves. It is calculated by dividing half the distance between the foci of the orbit by half the major axis. Its value may be anywhere between 0 (for a circle) and 1 (for a parabola). The eccentricity of the earth's orbit is 1/60, i.e., .017

echelon

A form of SPECTROSCOPE (q.v.) composed of a series of pieces of pane glass of equal thickness piled up like a stairway. Its important advantage lies in the production of high-dispersion spectra, but it has not been put to much use in astronomy.

echo

In radar technique, radio meteor astronomy and other applications employing the emission of radio frequencies, a wave reflected from one or more points and returned with a magnitude and time interval sufficient to be perceived and interpreted.

eclipse

The obscuration of one celestial body by another. It is usually restricted to the sun, moon and satellites of other planets. The hiding of a star by the moon or a planet is called OCCULTATION. There are different kinds of eclipses:

SOLAR, i.e., ECLIPSE OF THE SUN (q.v.).

LUNAR, i.e., ECLIPSE OF THE MOON (q.v.).

TOTAL. When sun or moon is entirely eclipsed.

PARTIAL. When the eclipse covers only a part of the sun or the moon.

ANNULAR. When the moon appears smaller than the sun, and so leaves a ring (annulus) of light around it as it crosses the sun's disk.

TOTAL ANNULAR. When the eclipse begins and ends as an annular, but is total over a part of its path.

CENTRAL. When the centers of the sun, moon and earth are in the same straight line.

PENUMBRAL. When the moon passes through only the penumbra of the earth's shadow.

eclipse of Thales

A total eclipse of the sun on May 28, 585 B.C. Said to have

been predicted by Thales, and to have stopped a battle between the Medes and the Lydians.

eclipse of the moon

A lunar eclipse occurs when the full moon passes through the shadow of the earth.

Two eclipses (very rarely three) may occur each year, but there are many years with none.

Eclipses may be partial or total. The longest possible eclipse lasts 3 hours and 40 minutes, of which 1 hour and 40 minutes is total the other 2 hours partial.

A lunar eclipse is visible wherever the moon is above the horizon which is over more than half of the earth, because the earth turns during the eclipse.

In passing into the shadow the moon is darkened very gradually It can be seen during totality by the red light refracted into the shadow by the air around the earth.

More people see lunar eclipses than can see solar eclipses although they occur less often.

eclipse of the sun

Solar eclipses occur when the new moon passes between the earth and the sun and when the shadow of the moon reaches the earth They may be partial total or annular. (*see* ECLIPSE)

They do not occur every month because the orbit of the moon is inclined 5°9′ to the ecliptic and the shadow passes above or below the earth

Because the moon is small the shadow is not always long enough to reach the earth producing an annular eclipse

Two solar eclipses of some kind must occur every year. Five may occur.

Total eclipses of the sun are visible only in a path about 150 miles wide. The shadow sweeps across the earth at the average rate of 2,100 miles an hour.

The longest possible total eclipse is 7½ minutes. Usually it

is much shorter. A partial eclipse always is visible over a larger area and lasts longer.

eclipse seasons

The two times, at nearly opposite seasons of the year, when the sun is near to one of the nodes of the moon's orbit.

Because of the westward regression of the nodes, the eclipse seasons are more than half a month earlier from year to year.

eclipse year

The interval between two successive conjunctions of the sun with the same node of the moon's orbit.

Its length is 346.62 days.

eclipsing binary stars

see ECLIPSING VARIABLES.

eclipsing variables

BINARY STARS (q.v.), the orbit of which is nearly enough within our line of sight, so that every time one star passes between us and its companion, it causes an eclipse. These binaries, of which about 1100 are known, can be subdivided into three broad types: (1) The Algol type, which remain practically of the same brightness between the minima, except for a small secondary minimum produced by the eclipse of the substantially less luminous secondary by the primary; (2) the β Lyrae type, with marked secondary minima and more rounded LIGHT CURVES (q.v.) with components elongated in shape by their mutual gravitational attraction; (3) the W Ursae Majoris type, with light curves conspicuously convex upward eclipses, composed of two much elongated, rather dense dwarf stars revolving almost in contact. The periods of the first two types range from one-fifth of a day to as much as 27 years, whereas for the third type they vary between much narrower limits, i.e., from about one-fifth of a day to a day and a third.—Another commonly applied classification of these variable stars is: the *dark eclipsing variables* (the Algol-type, consisting of a bright primary and an almost dark com-

panion which eclipses the primary once during each revolution), and *bright eclipsing variables* (the β Lyrae type, consisting of two luminous bodies, so that in each period there are two minima, and their depths depend on the relative brightness of the two bodies concerned).

ecliptic

The apparent path of the sun among the stars during a year. Strictly, it is the projection of the plane of the earth's orbit on the celestial sphere. It is a great circle inclined 23½° to the celestial equator. It cuts the equator at two points, the equinoxes. the points where it is farthest from the equator are the solstices.

ecliptic limits

Solar limits. The distance of the sun from the node, beyond which an eclipse is impossible and within which it is inevitable.

These major and minor limits are 18°31′ and 15°21′.

Lunar limits. The greatest distance of the sun from the node at which an eclipse of the moon is possible.

The major and minor limits are 12°15′ and 9°30′

ecliptic system

A system of CELESTIAL COORDINATES (q.v.) in which the ecliptic is the primary and the great circles perpendicular thereto are the secondaries.

ecosphere

A layer in a sphere inhabited by living organisms or suitable for the life of such organisms, as a layer of space about the sun extending from and including Venus through Mars, or the BIOSPHERE of the earth, especially that part of the troposphere extending to about 13,000 feet.

eddy

A more or less circular motion in a moving fluid, produced by an obstruction in its path. Eddies in the atmosphere are rotary movements of parts of the air streams, and are created

by friction at the surface of the earth, mountains, and other obstacles.

effective atmosphere

That part of the atmosphere which effectively influences a particular process or motion, its outer limits varying according to the terms of the process or motion considered.

effective temperature

The effective temperature of a star is the temperature calculated by the radiation laws and formulas, from the observed quantity and quality of the star's radiation.

efficiency of luminous bodies

The proportion of energy given off that produces visible light.

A candle uses 8 watts of energy to give 1 candle of light.

A Mazda electric bulb gives 1 candle for 1 watt.

The sun gives 8 candles for every watt. Therefore the sun is about 64 times more efficient than the candle.

Einstein shift

The shift toward the red that the spectral lines of visible light undergo when emerging from a strong gravitational field, such as that of a dense star; the immediate cause of this shift is a minute reduction in frequency of the emerging light. This shift, postulated by Einstein's theory of relativity, has been actually observed in the spectrum of the sun and also in that of the Companion of Sirius.

Einstein's spherical universe

A mathematical model of a STATIC UNIVERSE (q.v.) worked out by Einstein, based on the concept of COSMIC REPULSION (q.v.) introduced, but later repudiated, by him.

Electra

(1) One of the stars of the Pleiades, called "The lost Pleiad." —(2) The 130th asteroid.

electric arc

A very hot and brilliant light, produced by an electric current jumping a narrow space between two conductors.

electric field

The region in space in which an electric charge exerts a measurable effect.

electrogravitics

A proposed designation of the recently suggested field of research on the possibility of a direct control of gravity.

electrojet

A concentrated stream of electricity of limited width, believed to be produced by an intensification of atmospheric electric sheet currents usually present over the magnetic poles, and they form the boundaries of the zones of the AURORAE (q.v.). There is a strong electrojet flowing westward on the morning side of the earth, and a weaker one flowing eastward on the evening side, with a zero-current area where the two meet.

electromagnetic radiation, electromagnetic spectrum

A collective term for all known radiation, from the shortest-waved gamma rays (wavelength between 10^{-10} and 10^{-9} centimeter) through x-rays, ultraviolet, visible light, infrared waves, to the Hertzian or radio waves (wavelength ranging to 30,000 meters).

electromagnetic theory of light

About 1860 it was suggested that light waves were electromagnetic in character; if an electric current could be reversed rapidly enough, in a wire no bigger than a light wave, the electromagnetic field out in space would be identical with light.

electrometer

An electrical measuring instrument that can be used to

measure small electric currents, such as are associated with radiation detection.

electron

A negatively charged particle conceived to be revolving about the nucleus of an atom, much as planets revolve about the sun.

There are, in any atom, just as many electrons as there are protons in the nucleus of that atom.

The electron is the smallest unit of electric charge. It is the lightest particle known. Its weight is given as .000549, or 549 millionths of the weight of a hydrogen atom. It would take 311×10^{26} (that is 311 followed by 26 zeros) of them to weigh an ounce.

electron telescope

An instrument in which optical lenses form an infrared image of the object observed on the cathode of an electron image tube which then renders it visible.

electron volt

A unit of energy, equal to the energy gained by a particle of unit electrical charge in being accelerated through a potential difference of 1 volt. ("Million electron volt" is abbreviated as *mev*, and "billion electron volt as *Bev.*)

element

see CHEMICAL ELEMENTS.

elements of planetary orbits

The specifications necessary to define the orbit and to fix the place of the planet at any time.

1. Inclination to the ecliptic.
2. Longitude of the ascending node.
3. Angle from ascending node to perihelion point.
4. Semi-major axis.
5. Eccentricity.
6. Time of passing perihelion.

elevated pole

The CELESTIAL POLE (q.v.) above the horizon, which takes the name of the latitude, north or south. Thus, for an observer in north latitude the north celestial pole is the elevated pole.

elevation

A synonym for altitude

The angular distance of a celestial object above the horizon.

ellipse

One of the CONIC SECTIONS (q v)

A plane curve on which the sum of the distances from any point of its circumference to two points within called the foci, is always constant and equal to the major axis

elliptical galaxy

The designation applied to those EXTERNAL GALAXIES (q.v.) which show shapes ranging from spheroidal to elliptical or lenticular without any readily discernible structural feature, they are generally systems of stars of Population II, free of interstellar dust These galaxies are designated by the letter E followed by a number from 0 to 7, which indicates their ellipticity (Class E0 being the circular galaxy, while E7 the most flattened type which appears like a convex lens viewed edgewise) They are also referred to as *spheroidal galaxies*

ellipticity of a planet

The same as oblateness Its deviation from a sphere, because of flattening at the poles

It is found by dividing the difference between the equatorial and polar diameter by the equatorial diameter

For the earth it equals 1/297

elongation

The angular distance between a planet and the sun, as observed from the earth, in the direction in which the object stands from the sun The maximum possible elongation for

an inferior planet is called its GREATEST ELONGATION; it is 28° for Mercury, and 48° for Venus. The elongation of a satellite is its angular distance from its planet. The elongation of the moon may vary between 0 and 180° either east or west; the same may apply to the superior planets.

emersion

The reappearance of a celestial body after its eclipse, occultation or conjunction with the sun.

emission nebulosities

Luminous intragalactic "clouds," detectable by red-sensitive, photographic plates.

emission spectrum

A spectrum emitted by incandescent gases under low pressure; synonymous with BRIGHT-LINE SPECTRUM (q.v.).

Enceladus

A satellite of Saturn. (*see* SATELLITES OF THE SOLAR SYSTEM.)

Encke's Comet

The first known member of Jupiter's family of comets. It has the shortest period of any known comet, 3.3 years. It has been seen at every return since 1819.

It is one of the faintest comets known.

Encke's division

see CASSINI'S DIVISION.

encounter theory

see COLLISION.

energy

The capacity of a body or system for doing work. (*see* CHEMICAL ENERGY, KINETIC ENERGY, NUCLEAR ENERGY, POTENTIAL ENERGY, RADIANT ENERGY.)

enhanced line

A spectral line of extraordinary or exceptional intensity, produced by a spark or some other source of exceptionally high

temperature; as more and more atoms of a gas or gaseous body are ionized owing to a constant rise in temperature, more and more of these lines appear or become strengthened in its spectrum.

epact

(1) The period which would have to be added to the lunar year (12 moon months) to make it equal to the solar year. This is called the *annual epact*, and is about eleven days.

(2) The moon's age at the beginning of the calendar year.

(3) The excess of a calendar month over a lunar month. This is the *monthly epact*

ephemeris (plural: ephemerides)

A list or table of the computed positions which a celestial body occupied or will occupy on certain dates; these computations are made on the ground of observations that have determined the elements of the orbit

The American Ephemeris and Nautical Almanac is published every year by the United States Government It is a book containing tables of the positions of the sun moon, planets and some stars at frequent intervals through the year It gives data concerning eclipses and other facts that are useful to astronomers and navigators

England France, Spain Germany and other countries publish such annuals.

epicycle

In the Ptolemaic system of planetary motions the earth was supposed to be the motionless center, and the sun and planets to revolve about it. To explain the motions of the planets they were supposed to revolve eastward on small circles, *epicycles*, whose center, the fictitious planets, revolved eastward about the earth on larger circles, called *deferents*.

epoch

A date selected as a point of reference, or beginning of a new period, or era.

The epoch, or beginning of the Julian era, was Jan. 1, 4713 B.C.

epoch of a planet

The mean longitude of the planet, as seen from the sun, at a given date.

equation of the center

The angle that represents the difference between the true longitude and the mean longitude of a planet.

equation of time

The difference between mean solar time and apparent solar time (*see* TIME), i.e., between the right ascensions of the MEAN SUN (q.v.) and the true sun. It is considered positive and marked + if the apparent time is greater than the mean time, otherwise it is referred to as negative and marked —. It has a maximum value of about 16 minutes (+ 16 minutes twice a year, and — 16 minutes twice a year) and reduces to 0 four times a year.

equator

In geography, the line drawn around the earth, halfway between the north and south poles.

In astronomy a line drawn around the celestial sphere, halfway between its poles.

We might call it the intersection of the plane of the earth's equator with the celestial sphere, or a line drawn all the way around the sky exactly overhead at the earth's equator.

The galactic equator is a circle drawn through the middle of the Milky Way.

equatorial bulge

The deviation of a celestial body from a spherical shape, owing to its rotation. (E.g., the equatorial diameter of the earth is 7926.68 miles, whereas its polar diameter is 26.7 miles less, or 7899.98 miles.)

equatorial horizontal parallax

see PARALLAX.

equatorial telescope

An astronomical telescope that revolves about an axis parallel to the axis of the earth; once it has been set on a star, it keeps that star in the field of view automatically. To accomplish this, it is mounted so as to turn on two axes that are at right angles to each other: the *polar axis* is parallel to the earth's axis, and turns on fixed bearings at the top of the pier. Around it the telescope turns parallel to the celestial equator, and so follows a star across the sky.

The *declination axis* is supported by the polar axis. Around it the telescope turns along an hour circle from one declination to another.

equilibrium of stars

It is supposed that the interior of a star is in a state of mechanical equilibrium, such that the heat at any point within the star supplies just enough outward pressure to support the weight of the gas above it.

Thermal equilibrium requires that the temperature at any point remain the same in spite of the continual flow of energy from one part of the star to another.

If these two things were not balanced, the star would either collapse or explode.

equinoctial

see CELESTIAL EQUATOR.

equinoctial circle

The celestial equator. (*see* EQUATOR.) So called for the equinoxes, the two days in the year when the day and night are of equal length. (*see* EQUINOX.)

equinoctial colure

The HOUR CIRCLE that passes through the EQUINOXES (q.v.).

It is analogous on the celestial sphere to the prime meridian on earth, i.e., to the MERIDIAN OF GREENWICH (q.v.).

equinox

The times when the sun crosses the equator. There are two:

Vernal equinox. The beginning of spring, when the sun crosses from south to north on March 21.

Autumnal equinox. The beginning of autumn when the sun crosses from north to south on September 22 or 23.

The word equinox means "equal night." The equinoxes are the two days in the year when the night and day are of equal length, and the only two days when the sun rises exactly in the east and sets in the west, when, for people on the equator, the sun is directly overhead (on the zenith) at noon. They are the days when "the sun crosses the line." The line that it crosses is the celestial equator.

The word *equinox* also means the place on the celestial sphere where the sun crosses the celestial equator. The *vernal equinox* is the more important one. It is the point from which celestial longitude or right ascension is measured. It is the zero hour angle, and sidereal time is measured from its crossing of the meridian.

It is also called the "First Point of Aries," because Aries was, in ancient times, the position of the sun at the beginning of spring. Due to precession, this is no longer true. (*see* PRECESSION OF THE EQUINOXES.)

Equuleus [the Little Horse]

A northern constellation (near Aquarius).

era

A period of time, beginning at a certain date or epoch.

Eratosthenes

A Greek mathematician who lived in Alexandria, Egypt, 276-194 B.C.

The first man who measured the circumference of the earth. He learned that at Syene, (Assuan, Egypt) at noon on

June 22, the sun shone on the bottom of a deep well, indicating that the sun was directly overhead, and Svene was on the tropic of Cancer. At Alexandria, on the same day the sun was 7¼ degrees south of the zenith. "Seven and a quarter degrees is the fiftieth part of an entire circumference; and the distance between the two towns is five thousand stadia; hence the circumference of the earth is 50 times this distance, or 250,000 stadia." A stadium=607 ft. which makes his measure of the earth's circumference 28,740 miles (From *Astronomical Myths*, by Flammarion, p. 297.)

Eridanus [the River]

A long, crooked line of stars beginning near Rigel in the foot of Orion, and winding west and south to the 1st magnitude star Achernar, far below our southern horizon.

It represents the river into which Phaeton fell from the runaway chariot of the sun when struck by Jupiter's thunderbolt. (*see* CYGNUS.)

Eros

see ASTEROIDS.

errors of observation

No observations can be made with absolute precision. There will always be small errors that must be taken into account.

These fall into two classes.

ACCIDENTAL ERRORS (q.v.) and SYSTEMATIC ERRORS.

eruptive prominence

A PROMINENCE (q.v.) on the sun that is hurled forth from active material above the chromosphere and reaches high altitudes at great velocities.

escape velocity

see VELOCITY OF ESCAPE.

establishment

At any point, the average interval between the meridian

transit of the moon and the next high tide. Same as *lunitidal interval.* (*see* TIDES.)

ether

A semi-scientific, semi-philosophical concept of a medium to be found permeating space, penetrating all matter and highly elastic. Such a medium would help in the description of such phenomena as the transmission of light and other electromagnetic phenomena. The existence of ether has not been proved or disproved, and there is no unanimity among scientists, except to acknowledge that the idea, while not essential, is helpful.

Europa

A satellite of Jupiter. (*see* SATELLITES OF THE SOLAR SYSTEM.)

evection

This is the largest, and the first discovered, of the perturbations, or irregularities in the motion of the moon. It depends upon the alternate increase and decrease of the eccentricity of the moon's orbit, due to the changing direction of the attraction of the sun. It puts the moon forward or backward about 1 1/4° during a period of 1 1/8 years. It may affect the time of an eclipse making it anywhere from 3 hours early to 3 hours late.

evening star

The designation applied to a naked-eye planet when it sets after the sun; it is therefore a misnomer, since the celestial body concerned is not a star at all.

Evershed effect

Evershed, in India, discovered from the spectra of sunspots that were not near the center of the sun's disk, the spectral lines showed motion toward the observer on the side of the spot nearer the center, and away from the observer on the side nearer the limb.

This meant that the gases in the spot were moving radially away from the spot center.

evolutionary theory of the universe

The view that galaxies evolve, change and "grow old." (*see* EXPANDING UNIVERSE, STEADY-STATE THEORY OF THE UNIVERSE.)

excitation

The addition of energy to a nucleus, atom or molecule, with the result that it is transferred from its normal state ("ground state") to an "excited state."

excitation energy

The energy required to change a nucleus, atom or molecule from its "ground state" ("normal state") to an "excited state."

excited atom

An atom in which an electron has been lifted to a higher orbit. (*see* ATOM.)

exhaust

(ASTRONAUTICS) The burnt gases that leave the combustion chamber of a rocket.

exhaust velocity

(ASTRONAUTICS) The velocity with which the exhaust leaves a rocket; it equals the *specific thrust* multiplied by *g* (the acceleration).

exosphere

The outermost layer of the earth's atmosphere, above the IONOSPHERE (q.v.); it blends into outer space.

exotic fuel

A rocket fuel considered to be unusual, as liquid hydrogen with a fluorine oxidizer.

expanding universe

The RED SHIFT (q.v.) of the lines of the spectra of the distant galaxies has been interpreted as an indication of a mutual recession of the galaxies; the universe seems to be expanding (much like a balloon that is being inflated), so that the galaxies appear to be flying away from each other at tremendous

speeds, and the farther they are the faster they seem to be moving. The original theory of Lemaître postulated that the origin of our universe had been a giant "primordial atom" that exploded as a result of violent radioactive decay processes. This theory has, however, been discarded as inconsistent with more recent findings and conclusions. One current view is that until 5 billion years ago (*see* AGE OF THE UNIVERSE) our universe was collapsing, shrinking or condensing at a uniform rate from a state of a maximum, infinite rarefaction toward a state of maximum compression, which it ultimately reached 5 billion years ago; when that state of maximum compression had been reached, the process reversed itself, and the present expansion toward an infinite rarefaction began again.

Explorer I

The first U.S. artificial earth satellite placed successfully into an orbit, with the aid of a four-stage Jupiter C rocket fueled by Hydyne, on January 31, 1958. This satellite is a slender, tubular projectile-shaped object, 80 inches in length, weighing 30.8 lbs., carrying its payload of 11 lbs. of scientific instruments at a velocity of 18,000 miles per hour. Its orbit is inclined 35° to the equatorial plane, has a perigee of less than 200 miles and an apogee of close to 1800 miles. The satellite completed its first revolution around the earth in an orbit time of 118 minutes. Its official designation (cf. NOMENCLATURE OF ARTIFICIAL SATELLITES) is *Satellite 1958α*.

explosive decompression

Physical and physiological phenomena caused by sudden decrease in atmospheric pressure.

exterior systems

see GALAXY.

external galaxy

An EXTRAGALACTIC NEBULA (q.v.), now known to be another

galaxy like our own Milky Way System. Formerly called *island universe.*

extragalactic

Beyond our galaxy, the Milky Way. (*see* GALAXY.)

extragalactic nebulae

NEBULAE (q.v.) found all over space outside of our galaxy; they are recognized today to be *external galaxies.* They can be classified, according to Hubble, as follows: (1) *spiral,* subdivided into *normal spirals* and *barred spirals*; (2) *elliptic* (or *spheroidal*); (3) *irregular.* (The spiral and elliptical nebulae are referred to jointly as the *regular* nebulae or galaxies.)

eye lens

The smaller lens of the EYEPIECE (q.v.), of a telescope, placed opposite the field lens.

eyepiece

In a telescope, the lens or lens system through which the observer views the image formed, and which magnifies that image for better and more efficient viewing. Modern eyepieces consist of a system of at least two lenses, the larger of which is called the *field lens,* and the smaller one the *eye lens.* The simplest systems can be classified broadly in two groups: POSITIVE and NEGATIVE eyepieces (q.v.) according to the shape and arrangement of the two lenses. (*see also* SOLAR EYEPIECE.)

F

F corona

The outer layer of the corona of the sun.

F layer

see APPLETON LAYER.

f-number

The FOCAL RATIO (q v.)

faculae

Large, bright spots or streaks on the sun. They are most conspicuous near the edge and near sunspots They are probably the same material as the rest of the photosphere, but are thought to be elevations projecting above it—perhaps like mountains, but mountains of gas.

Fahrenheit

The thermometer scale used in England and the United States.

0° is the temperature of a mixture of ice and salt. It is 32° below the freezing point of water.

The boiling point of water is 212°F.

faint companion stars

Many bright stars have faint companions. (*see* COMPANION OF SIRIUS.) Procyon was suspected of having a companion in 1840 but it was not observed until 1896. Like that of Sirius, it is a small, very dense star. Mira the variable star in Cetus, has a small companion of the 10th magnitude. It was dis-

covered because the spectrum of Mira, at its faintest phase, showed some bright lines that ought not to be there. In 1923, when Mira was very faint the small companion was observed nearly a second of arc away.

falcate, falcated

Crescent-shaped. (This term is usually applied to the moon, Mercury and Venus when they show their crescent phases.)

Falcon

A short-range (4 miles) solid-propellant-powered guided air-to-air missile of the U S Air Force

"falling stars"

Stars do not fall Stars are suns, huge, hot, shining balls of gas, that stay in their places

The little points of light that seem to fall are METEORS (q v).

families of asteroids

It was discovered that there are groups of asteroids whose orbits are very similar, and bear close relations to the orbit of Jupiter Eleven in one family are called the Trojan Asteroids.

Hirayama, a Japanese astronomer, has drawn attention to four other families whose orbits differ little, and are somewhat related to Jupiter's orbit He suggested that each family originated from the breaking up of a single body

family of comets

see COMET FAMILY

Farside

see OPERATION FARSIDE

Fechner's law

The law that the intensity of a sensation increases as the logarithm of the stimulus

It is used in comparing the magnitude of stars, but holds good only for middle ranges of intensities.

ferry rocket

(ASTRONAUTICS) The final STEP (q.v.) of the planned piloted space vehicle, designed for transporting personnel between the earth and the terminal orbit.

fictitious planet

In the Ptolemaic system, the imaginary center of an EPICYCLE (q.v.) which revolved about a stationary earth along a large circle called a DEFERENT (q.v.).

field

An area or region. With reference to a specific force (as in *field of gravity*, etc.) that portion of space in which the effects of that force can be observed or detected.

field of the telescope

The area visible through the lens system of the telescope.

field of view

The area over which the image is visible in the eyepiece of a telescope. Also, a synonym of FIELD OF THE TELESCOPE (q.v.).

field lens

The larger one of the two lenses of the EYEPIECE (q.v.) of a telescope, placed opposite the *eye lens*.

field stars

The stars in the background when a specific object is being studied or observed.

figured

Said of an optical lens that has been given the proper curvature.

filaments

Irregular, narrow lines seen in spectroheliograms of the sun. Some are bright and some dark.

The dark ones are called hydrogen flocculi.

filar micrometer

An instrument for measuring very small distances in the field of an eyepiece. It consists essentially of two spider threads parallel to one another; one is fixed, the other movable and controlled by a fine screw with a graduated head and a counter of its revolutions.

filter

In general, a sheet or plate of a suitable substance that is interposed between the source of a radiation and the observer or some exposed object to absorb selectively a part of the radiation. In telescopes, spectroscopes, photographic cameras, etc., a device of glass or other suitable material attached to the apparatus in order to control the quantity or wavelength of light passing through the latter. When observing the sun, very dark filters must be used to avoid injury to the eye.

finder

A small telescope, with a wide angle lens, attached to the tube of a large telescope and pointed at the same spot in the sky.

It is easier to find the object to be observed in the smaller telescope, and bring it near the center of the field, so that it will be in the field of the larger lens.

Sometimes two rings, with no lens, are used for rough adjustment. They work like the sights on a gun.

fire balls

Brilliant meteors that leave a visible trail as they move across the sky.

They are often as bright as Venus and may even exceed the full moon.

They sometimes seem to move slowly and are seen for several seconds. (*see* METEORS.)

firmament

The vault or arch of the sky.

The ancient Hebrews thought the earth was flat, surrounded

by the ocean and covered by a solid, material dome that separated "the waters that are above the firmament from the waters below the firmament."

First Point of Aries

The point where the ecliptic crosses the celestial equator from south to north. Symbol: ♈ This intersection of ecliptic and equator is the vernal equinox. It is now in the constellation Pisces. It is used as the zero point for measuring celestial longitudes on the ecliptic, right ascension on the celestial equator, and sidereal hour angle.

First Point of Libra

The point where the ecliptic crosses the celestial equator from north to south.

This is the autumnal equinox.

It is now in the constellation Virgo.

first quarter

The phase of the moon when it is in the eastern QUADRATURE (q.v.) and is visible as a semicircle. (*see* PHASES.)

fission

Splitting. The term used to designate the splitting of atoms, especially of uranium, in the production of atomic energy (*see* NUCLEAR FISSION.)

fission theory

Formulated to explain the formation of double stars.

A star of low density, rotating slowly, shrinks under the action of gravity. It rotates faster and becomes flattened at the poles. Faster rotation and flattening eventually make it elliptical, then a dumbbell shape, and then it separates into two stars.

After separation tidal friction causes the stars to move farther apart.

This theory accounts satisfactorily for spectroscopic binaries of small separation, but probably could never cause wide enough separation to produce a visual binary.

Fitzgerald contraction

The idea that as any object approaches the speed of light it grows smaller in the direction of its travel.

fix

In NAUTICAL ASTRONOMY (q.v.), an accurate determination of latitude and longitude.

fix, running

Fix determined by two lines of position with a delay, possibly of hours, between them

fixed star

A term used originally to distinguish the stars, which kept the same position with respect to other stars, from the planets which were called "wanderers" or wandering stars, because they were seen to move among the other stars.

Also the stars were thought to be fastened to the firmament, or sky, which was supposed to turn around the earth every day.

Actually no star is "fixed" All are in motion.

flame spectrum

The spectrum obtained by volatilizing a substance in a flame

flare

see SOLAR FLARE

flare star

A designation applied to certain red main-sequence stars which are subject to sudden, very brief, intense outbursts over limited areas of their surfaces which are reminiscent of SOLAR FLARES (q.v.) and have been observed to increase the brightness of the star by more than 1 magnitude for periods generally less than an hour

flash, green

see GREEN FLASH.

flash spectrum

When an eclipse of the sun becomes total, just as the photosphere becomes hidden, the dark-line spectrum suddenly changes to a bright-line spectrum, in which the lines are a series of bright crescents, images of the narrow crescent of the chromosphere in different colors.

The flash spectrum can be observed for only a few seconds at the beginning and at the end of totality.

It is useful in measuring the depth of the reversing layer of the sun's atmosphere and the distribution of the most abundant gases in it.

flocculi

Bright and dark patches on the surface of the sun, shown best in spectroheliograms. They are masses of gas, which when bright are hotter and when dark are cooler than the surrounding surface.

Bright flocculi are usually calcium, and are conspicuous in sunspot zones, and in the higher levels of the sun's atmosphere.

Hydrogen flocculi are more often dark, and are elongated, and curved as they whirl in the vortices around the sunspots.

flood current

Horizontal motion of water toward the land as the tide is rising. (*see* TIDES.)

fluorescence

The emission of electromagnetic radiation as the result of exposure to some other radiation, which emission ceases when the stimulus that produces it ceases to act on the emitting substance. Thus light passing through a gas, may change the energy state of the atoms and cause them to emit light of a different wavelength.

X-rays, which are invisible, falling on a fluorescent screen, cause it to glow with visible light.

flux

With reference to electromagnetic radiation, the power or energy that passes through a surface per unit time.

flux density

The FLUX (q.v.) per unit area. It is often called the *intensity* of the beam.

flux of radiation

Radiant energy traveling across a given surface in a given direction is said to form a BEAM.

The RADIANT FLUX is the amount of energy that flows along the beam per unit of time.

"flying saucer"

A colloquial term for allegedly sighted unidentified flying objects in the sky, which have been the topic of a great many conflicting and controversial speculations, theories and literature.

focal length

In a telescope or other optical instruments, the distance between the lens or mirror and the focus.

focal plane

The plane that passes through the focus, perpendicular to the axis of the lens, this is the plane in which the image formed by the lens is of optimal sharpness.

focal ratio (f/ratio)

The ratio between the FOCAL LENGTH (q.v.) and the diameter of a lens or mirror. It is the focal length divided by the diameter of the lens or mirror. (Also called *f-number*.)

focus (plural: foci)

(1) The foci of an ellipse are two points on the major axis, equidistant from the center; the sum of the distances of any point of the circumference of the ellipse from the foci is constant. In elliptical orbits, the primary is in one of the foci. (A parabola or a hyperbola has only one focus.) (2) With

reference to lens or mirror, that point to which rays converge or from which they appear to diverge. In optical instruments, that point on the optical axis of the lens or mirror to which it makes the incident light converge; this is the point at which the sharpest image of a distant point or object, situated likewise on that axis, is formed.

Fomalhaut

The traditional name of the star α Piscis Austrinis (*see* STARS—*Plate X*).

footpoint

see GEOGRAPHICAL POSITION.

forbidden lines

The designation of certain spectral lines which are produced by certain extremely rarely occurring, improbable transitions (called *forbidden transitions*), so that their occurrence under ordinary laboratory conditions is extremely unlikely.

force

In general, any physical cause capable of modifying the motion of a body, or of producing an acceleration in the motion of a body that is free to move.

force of inertia

The force with which a body resists all changes in its state of rest or motion (*see* INERTIA).

Fornax [the Furnace]

A southern constellation (near Eridanus).

Foucault pendulum

A heavy ball on a very long cord, so mounted as to be free to swing in any direction and with very little friction at the point of support. Under the ball is a compass card to show the direction of swing.

Such a pendulum will continue to swing for a long time in

the plane in which it was started. The turning of the earth rotates the floor under the pendulum, and so slows the rotation of the earth.

At the poles it would turn all the way around in 24 hours. At the equator it does not turn at all. At 40° latitude it turns 10° an hour, or a full circle in 36 hours.

Invented by Foucault in France in 1851. The rotation is clockwise in northern hemisphere, counterclockwise in the southern one

Fraunhofer lines

Dark lines which are seen crossing the band of color in the solar and stellar spectra

They were studied by Joseph Fraunhofer, a German, in the sun spectrum in 1814, and in star spectra in 1823. He counted 750 lines and mapped 350 of them quite accurately.

They were often observed, but their important significance remained unknown until 1859, when Kirchhoff, another German, found that they indicated the chemical composition of the sun and the stars

free ascent

(ROCKETRY) The upward journey of a rocket after its motor has stopped operating Also called *coasting*

free fall

(ASTRONAUTICS) The state of unobstructed and unrestricted motion under the effects of a gravitational field, thus, the condition of a rocket or missile when it coasts in outer space with its driving power off, producing an effect equal to that of ZERO-GRAVITY (q v)

frequency

In general, the number of the repetitions of a periodic process per unit time With reference to an electromagnetic radiation, the number of waves passing a given point per

second. It equals the velocity of the radiation divided by its wavelength.

friction

Rubbing together. The force of retardation of two moving bodies that are in contact with each other.

friction of tides

see TIDES.

frigid zones

The areas around the north and south poles of the earth, above 66½° north or south latitude, where the sun is circumpolar for some part of the year.

fronts

The edges of cold or warm air masses that move across the surface of the earth and cause changes of weather.

full moon

The phase of the moon when it is in OPPOSITION (q.v.) to the sun and is visible as a full disk. (*see* PHASES.)

fundamental circle

In a system of coordinates, the great circle the plane of which is assumed to be "horizontal" and for which the system is named (e.g., the celestial horizon in the horizon system, the celestial equator in the equatorial system, etc.).

furnace spectrum

Spectrum of material heated to incandescence or vaporized in an electric furnace.

The temperature is relatively low, below 5000°F.

G

g

The symbol for ACCELERATION OF GRAVITY, or simply for GRAVITY (q.v.). In astronautics, *1g* indicates normal earth gravity, i.e., the gravity on the surface of the earth that imparts an acceleration of 32 feet per second to a body in free fall; *2g*, *3g*, etc. are the double, triple, etc. of this force. (*see* ZERO-GRAVITY.)

galactic absorption

The absorption of light by interstellar matter in the galaxy. (*see* ABSORPTION OF STARLIGHT.)

galactic center

The gravitational center of the Milky Way galaxy, about which the sun and the other stars of our galaxy revolve; it is assumed to be about 30,000 light years from our sun in the direction of Sagittarius, at galactic longitude 325°, hidden from our solar system by vast star clouds and dark nebulae.

galactic circle

That great circle on the celestial sphere which is inclined 62° to the celestial equator with its ascending node in right ascension $18^h\ 44^m$. It is the fundamental circle of the galactic system of coordinates.

galactic clusters

see CLUSTER.

galactic concentration of stars

William Herschel, in England, in 1783 made counts of the

stars in equal areas of the sky, selected in many parts of the visible heavens. He found that the numbers always increased as he approached the Milky Way from either side.

From this he, and, others later, reached the conclusion that our system of stars has the shape of a lens or a grindstone. (*see* GALAXY.)

galactic coordinates

Reference circles and points used, in problems relating to the galactic system, for determining the location of a body with reference to the Milky Way.

galactic equator

A GREAT CIRCLE (q.v.) halfway between the GALACTIC POLES (q.v.) and about one degree north of the center line of the Milky Way.

galactic latitude

A GALACTIC COORDINATE (q.v.); angular distance measured perpendicularly from the GALACTIC EQUATOR.

galactic longitude

A GALACTIC COORDINATE (q.v.); distance measured eastward along the GALACTIC EQUATOR (q.v.) from its intersection with the CELESTIAL EQUATOR (q.v.).

galactic nebulae

see NEBULA.

galactic noise

The radio waves ("noise") that reach us from our own galaxy.

galactic plane

The plane drawn through the galactic equator, near the center of the Milky Way. It is inclined 62° to the plane of the celestial equator.

(For measurements from it *see* GALACTIC COORDINATES.)

galactic poles

The two opposite points that are farthest north and south of the Milky Way.

galactic radio noise

see GALACTIC NOISE.

galactic windows

Regions near the equator of the Milky Way where the absorption of light by interstellar clouds is so low that distant external galaxies can be seen through them.

galaxy

Defined by H. Shapley as "a *large* gravitational system of stars." Hundreds of thousands of galaxies have been photographed. A few hundred, near enough, have been studied in some detail. A dozen or fifteen are within two or three million light years of the earth.

They are generally divided into three classes:

1. *Spirals.* About 75%. These are watch-shaped or wheel-shaped, with a conspicuous hub, or bright center, and two spiral arms. (*see* SPIRAL GALAXY.)

2. *Elliptical* About 20%. Varying from spherical to rather long ellipsoidal with indefinite boundaries and no arms. (*see* ELLIPTICAL GALAXY.)

3. *Irregular.* About 5%. Irregular in form and structure or peculiar variants of the other forms.

The only spiral easily seen with the naked eye is the large one in Andromeda (q.v.), also called M. 31.

The external galaxies nearest to the earth are the two irregular MAGELLANIC CLOUDS, (q.v.) in the southern hemisphere of the sky.

The most distant objects ever photographed are some galaxies at the enormous distance of 500 million light-years.

(*see* LOCAL GROUP OF GALAXIES.)

Galaxy

The great system of stars of which our sun is a member; it

includes all the naked-eye stars as well as all that can be seen through ordinary telescopes. *Galaxy* (or *our galaxy*) is the designation usually employed when referring to the system in space, whereas it is customarily called the MILKY WAY (q.v.) when referring to its appearance on the celestial sphere. It is universally believed to have the general shape of a lens. It is about 100,000 light-years in diameter and 10,000 light-years thick. The sun is about 2/3 the distance, 30,000 light-years from its center, which is in the direction of Sagittarius.

The globular clusters are around the galaxy in a shape which is a flattened sphere.

The Galaxy is revolving at a terrific pace, about the distant center. Our sun is moving about 150 miles per second, completing one rotation in 200 million years.

There are millions of exterior galaxies far beyond ours.

galaxy of the second order

C. V. L. Charlier's term for a SUPERGALAXY (q v.).

Galilean satellites of Jupiter

The four largest and brightest of Jupiter's twelve satellites, were discovered by Galileo early in 1610. They are named Io, Europa, Ganymede and Callisto, but are often referred to as numbers 1 to 4 in the order of their distance from the planet.

They can be seen easily with a small telescope and could be seen with the naked eye if the planet were not so bright. The first and second are about the size of our moon. The third and fourth are larger than Mercury.

Their orbits are nearly circular and almost in the plane of Jupiter's equator. Their periods of rotation and revolution are the same. Their distances from Jupiter are so great that on the planet their combined light would be only about one third of our full moonlight.

Galilean telescopes

In 1609 Galileo heard a rumor that a Dutch spectacle maker had invented an instrument that made distant objects appear

nearer and larger. He promptly made such an instrument for himself.

His first telescope was a short piece of metal pipe, about three feet long and 1½ inches in diameter with a lens at each end. It magnified about three diameters He called it an "Optic tube."

He soon built another, with a paper tube four feet long and two inches in diameter, which magnified 32 times. It had a convex lens at one end and a concave lens at the eye end. Such lenses are now used in opera glasses. They are not suitable for high power because of their very small field, and because of the chromatic aberration

With his small telescope Galileo made several discoveries. He saw the mountains on the moon, the phases of Venus, the four larger satellites of Jupiter. He discovered that the Milky Way was made up of myriads of stars. Saturn looked very elliptical, but he could not separate the rings from the disk.

Galileo presented a telescope to the Doge in Venice and received a life appointment and a doubled salary.

gamma ray

The shortest wave of all electromagnetic radiations, emitted by certain radioactive substances.

Ganymede

A satellite of Jupiter. (*see* SATELLITES OF THE SOLAR SYSTEM.)

gas laws

see AVOGADRO'S LAW, BOYLE'S LAW, CHARLES' LAW, LANE'S LAW. (Boyle's law and Lane's law are the ones that have important application in astronomy, since they permit the determination of the extremely high temperatures and enormous densities prevailing in the interiors of stars)

gauss

The standard unit for measuring a magnetic field.

A single loop of wire 0.628 cm. in r. ʾius, through which

flows a current of one ampere, will possess at its center a magnetic field of 1 gauss.

Gaussian constant

The acceleration due to the attraction of the sun at the mean distance of the earth from the sun.

Gay-Lussac's Law

see CHARLES' LAW.

gegenschein

A very faint glow that appears in the sky as an oval spot 5-8° in diameter (as large as the bowl of the Big Dipper) on the ecliptic, always exactly opposite to the position of the sun. It is also called the *counterglow.*

Geiger-Mueller counter or tube

A gas-filled tube, usually cylindrical in shape, so designed and operated as to produce a pulse of electrical charge as an ionizing particle passes through it.

Gemini [the Twins]

The third constellation in the zodiac. A large and bright group of stars northeast of Orion.

It represents the Greek twins, Castor and Pollux, sons of Leda and Jupiter and brothers of Helen of Troy. When after a violent storm, on the expedition of the Argonauts, the sailors saw bright stars on the heads of the twin brothers, they thought they must be gods.

They became the tutelary deities of sailors and warriors.

Pollux is a giant, first magnitude star.

Castor is not quite first magnitude. It is a beautiful double.

Near the star Tejat, in the feet of Castor is the position of the sun at the summer solstice, June 22.

Geminids

A meteor shower, the RADIANT (q.v.) of which is near α Geminorum (Castor); it reaches maximum about December 13,

when 20 bright, swiftly moving meteors may be seen every hour.

genetic effect

In radiobiology, inheritable changes resulting from the absorption of ionizing radiations.

Genie

An Air Force missile

geocentric

Viewed or considered from or referred to the center of the earth.

geocentric altitude

The altitude of a body as it would be observed at the center of the earth with a horizon parallel to the observer's horizon on the surface.

geocentric latitude

(1) *Celestial*: The LATITUDE (q.v.) of a celestial body seen from the center of the earth. (2) *Terrestrial*: The angle that the plane of the equator forms with the line linking the position of the observer with the center of the earth. (Owing to the flattening of the earth, the poles and the equator are the only places where the geocentric latitude equals the geographical latitude, the maximum difference is 11½ minutes of arc, at the latitude of 45°.)

geocentric longitude

The LONGITUDE (q.v.) of a celestial body assumed to be seen from the center of the earth

geocentric parallax

see PARALLAX.

geocentric position

The position of a planet, or other body, as seen from the center of the earth.

geocentric theory

The ancient theory that the earth was stationary at the center of the universe and the sun, the planets, the stars, and all other celestial bodies revolved about it daily.

geodesy

The study of the earth as a celestial body.

geodetic latitude

A synonym for GEOGRAPHICAL LATITUDE (q.v.).

geographic latitude

The angle between the line perpendicular to the surface of the standard spheroid and the equator plane, i.e., a distance measured perpendicularly from the CELESTIAL EQUATOR (q.v.). It is the ASTRONOMICAL LATITUDE (q.v.) corrected for station error, which is very small. It is also called *geodetic* or *topographical latitude*.

geographic longitude

Distance on the surface of the earth east or west of the meridian of Greenwich, measured in degrees or in hours (1 hour equals 15 degrees).

geographical coordinates

see COORDINATES.

geographical position

The point on earth at which a given celestial body is at the zenith at any moment.

geography

The study of the surface of the earth.

geoid

The earth regarded as a geometrical solid, the surface of which is the mean sea level extended continuously through all the continents. It approaches closely an ellipsoid of revolution.

geomagnetic poles

These represent the ends of the geomagnetic axis, which is

the center of the magnetic field that extends out all around the earth and attracts the electrified particles from the sun that cause the AURORA (q.v.). This axis is inclined at an angle of 12° to the geographic axis.

The north geomagnetic pole is near Etah in Greenland. The southern one is on the Antarctic Continent 1,100 miles west of Little America at latitude 78° south, longitude 111° east.

These poles are distinct from both the geographic and the magnetic poles.

geomagnetism

The TERRESTRIAL MAGNETISM (q.v.).

geometrical astronomy

That branch of ASTRONOMY (q.v.) which is concerned with defining and measuring the positions and motions of celestial bodies with relation to some fixed system of points, lines and planes.

geophysical constant

A quantity that expresses a fixed value for a law or magnitude that applies to the physics of the earth (e.g., the constant of nutation).

ghost

In spectroscopy, the designation of the false images of a spectral line or spectral lines resulting from irregularities in the rulings of the diffraction grating.

In telescopes, spurious images caused by reflection in the optical system.

giant planets

The four planets Jupiter, Saturn, Uranus and Neptune which are very different from the TERRESTRIAL PLANETS (q.v.).

They are vastly larger, much less dense, only a little heavier than water; their atmospheres and temperatures are entirely different from those of the other planets.

giant stars

A small class of stars which are twenty or thirty times larger than the sun, and more than 100 times more luminous.

Good examples are:

Capella, 16 times the diameter of the sun.

Arcturus, 22 times the diameter of the sun.

Aldebaran, 35 times the diameter of the sun.

(*see* RUSSELL DIAGRAM, SUPER-GIANT STARS.)

gibbous

Hunchbacked or lopsided. The moon (*see* GIBBOUS MOON), Mercury, Venus, Mars and Jupiter show the gibbous phase.

gibbous moon

The shape of the visible surface of the moon when the sun is illuminating more than half of the side facing the earth. This phase can be observed for the period extending from first quarter to full moon and from full moon to third or last quarter.

glare stop

A round blackened cardboard disk or a disk of some other suitable material, with a hole in the center, inserted in the objective tube of a telescope to block off all stray radiation entering from outside the field of view. Often two or more glare stops are used.

globe

see CELESTIAL GLOBE.

globular cluster

see CLUSTER OF STARS.

globular projection

A representation of a portion of the sky more or less as if it were a photograph of the inside of a hemisphere taken from a point .85 diameter from its center in the opposite direction.

globules

Small, black patches seen against the brighter background

of bright nebulae, which some astronomers think may be stars in the making

The pressure of starlight gently forces the gaseous mass into a spherical form of dwindling size, until gravitation can take over and complete the job

gnomon

The style pin or inclined plate of a sun dial That which casts a shadow

The sun dial should be set so that the gnomon points exactly to the celestial pole Its shadow on the dial tells the hour in local, solar time

gnomonic projection

Representation of part of the earth's surface by developing it from the center of the earth to a plane tangent at one point, called the point of tangency Meridians are straight lines converging toward the pole parallels of latitude are non-parallel curved lines unless the point of tangency is the pole in which case the parallels are concentric circles Angles are not correctly represented A great circle is a straight line

golden number

The numbers of the years in the METONIC CYCLE (q v) were engraved in gold on the walls of the temple of Minerva

The golden number is used in finding the date of Easter

gradient

The rate of change in the value of a quantity with distance in a given direction

grain

(ASTRONAUTICS) A rod like extruded length of solid rocket PROPELLANT (q v) also called *charge*

granules on the sun

The smallest visible markings on the photosphere

Through a telescope the surface of the sun has a mottled

appearance, with many brilliant granules scattered on the less luminous background.

They last only a few minutes and appear to be caused by convection currents, hot gases rising from lower levels in the sun.

grating

see DIFFRACTION GRATING, GRATING SPECTROSCOPE.

grating spectroscope

A SPECTROSCOPE (q.v.) in which the prism is replaced by a GRATING (q.v.) or by a piece of glass into which a series of parallel lines have been ruled.

gravitation

The universal attraction exerted by every particle of matter on every other particle. According to NEWTON'S LAW OF UNIVERSAL GRAVITATION, this force varies directly as the product of the masses of the particles and inversely as the square of the distance between them. (*see also* CONSTANT OF GRAVITATION.)

gravitational astronomy

A synonym for CELESTIAL MECHANICS (q.v.).

gravity

The effect, on the surface of a celestial body, of its GRAVITATION (q.v.) and of the centrifugal force produced by its rotation. On earth it is 981 cm. (32 feet) per second per second. (*see* ACCELERATION OF GRAVITY, ARTIFICIAL GRAVITY.)

gray body

A body which emits radiant energy, having the same relative spectral energy distribution as a black body at the same temperature, but in smaller amount.

great circle

A circle on the surface of a sphere (thus on the surface of

the earth or of the celestial sphere) cut by a plane that passes through the center of the sphere.

Great Comet of 1882

This was one of the finest comets of modern times. It was plainly visible in full daylight. It passed through the sun's corona within 300,000 miles of the surface, with a speed of 250 miles per second, or 1 million miles per hour.

After passing the sun it divided into four parts like beads on a string, and several smaller pieces moving on parallel paths.

It will probably return as four comets in about 900 years, but they may be separated by many years.

great sequence

see VARIABLE STARS.

greatest elongation

The maximum angular distance by which an inferior planet can possibly appear to be separated from the sun. The greatest elongation of Mercury is about 28°, and of Venus about 48°.

Greek alphabet

alpha	α	iota	ι	rho	ρ
beta	β	kappa	κ	sigma	σ
gamma	γ	lambda	λ	tau	τ
delta	δ	mu	μ	upsilon	υ
epsilon	ε	nu	ν	phi	φ
zeta	ζ	xi	ξ	chi	χ
eta	η	omicron	ο	psi	ψ
theta	θ	pi	π	omega	ω

green flash

The momentary green appearance of the uppermost part of the sun's disk, due to atmospheric refraction, as it sinks below, or rises above, the horizon.

greenhouse effect of an atmosphere

The glass roof of a greenhouse lets the short waves of sun-

light and heat pass through, but is nearly opaque to the longer heat waves that radiate from soil, plants and heating units inside. The atmosphere of a planet acts in the same way.

Sunlight and heat pass through the air without heating it, but they are absorbed by water and earth, and so heat the surface. Longer waves of heat radiate from the earth and are absorbed by the air, and these heat the air.

This gives a climate that makes life possible on the earth. The moon, with no atmosphere, has great and rapid changes of temperature between day and night, which help to make life there impossible.

Greenwich apparent time

Local hour angle of the apparent sun at Greenwich plus twelve hours. (*see* GREENWICH TIME, UNIVERSAL TIME.)

Greenwich hour angle

A local hour angle, measured westward from the celestial meridian of Greenwich. The angle at the celestial pole between the celestial meridian of Greenwich and the hour circle of a body.

Greenwich meridian

see MERIDIAN OF GREENWICH.

Greenwich sidereal time

Local hour angle of the vernal equinox at Greenwich, expressed in hours, minutes and seconds. (*see* GREENWICH APPARENT TIME, GREENWICH TIME.)

Greenwich time

The mean solar time at the meridian of Greenwich near London, England.

Standard time zones are 15° of longitude wide, either east or west of Greenwich. Standard time changes by one hour when crossing from one zone to the next.

Greenwich time kept by the chronometers of ships, and by comparing it with the local time, gotten by observations of

the sun or the stars, the longitude can be computed. (Cf. GREENWICH APPARENT TIME.)

Gregorian Calendar

The calendar in use now.

Due to the error of 11 min. 14 sec. in the length of the year in the Julian calendar, the date of the Vernal equinox slowly slid backward to Mar. 11 by 1582 instead of Mar. 21 as fixed by the Council of Nicea in 325 A.D.

Pope Gregory XIII ordered a reform in 1582 A.D. He dropped 10 days between Oct 4 and 15 of that year, and said that instead of 100 leap years in 400 years, there should be only 97. The century years should be leap years only when divisible by 400 instead of 4. So 1900 was not a leap year but 2000 will be. The Jesuit astronomer Clavius designed the Gregorian calendar.

The error in the length of the year is now only 26 seconds, which will not make a difference of one day until 3000 years have passed.

Gregorian telescope

A REFLECTING TELESCOPE (q.v.) using a large mirror with a hole in the center, with the EYEPIECE (q.v.) placed in it; a small concave mirror, placed on the principal axis, slightly outside the focus, reflects the light back into the evepiece.

group of galaxies

see LOCAL GROUP OF GALAXIES.

group of stars

A number of stars that move in the same direction and at the same speed.

The same as a moving cluster (*see* CLUSTERS OF STARS).

group parallax method

Stars in a cluster relatively close together and traveling at the same speed in the same direction, offer a means of finding their distance that is not possible for a single star.

It is possible to find the direction of motion of a cluster, by finding the point where their motions seem to come together at a vanishing point.

The real direction of each star's motion is along a line parallel to the line from the observer to this vanishing point.

Getting the star's radial velocity with the spectroscope, it is possible to solve triangles by trigonometry and find the distance of the entire group of stars.

Grus [the Crane]

A southern constellation.

guided missile

Any unmanned rocket or jet-propelled vehicle, used primarily for military purposes, that is, carrying or designed to carry a warhead, and the flight path or trajectory of which can be controlled and modified by a suitable mechanism located either within the guided unit itself, or at the launching site, or elsewhere. The guidance (*see* INERTIAL GUIDANCE SYSTEM, CELESTIAL NAVIGATION SYSTEM) may be divided essentially into three stages: the *launching phase*, the *mid-course guidance*, and the *terminal guidance*. Guided missiles are divided into four broad categories: air-to-air missiles (AAM), air-to-surface missiles (ASM), surface-to-air missiles (SAM), and surface-to-surface missiles (SSM). Their importance in astronautical research derives from the suitability of many models for being used as upper-air research vehicles and for launching artificial satellites.

gyro-compass

A compass consisting of a continuously driven GYROSCOPE (q.v.) whose supporting ring confines the spinning axis to a horizontal plane, so that the earth's rotation causes it to assume a position parallel to the earth's axis, and thus to point to the true north. This mechanical compass is highly insensitive to magnetic disturbances.

gyroscope

A wheel or disk so mounted as to spin rapidly about an axis, and also free to rotate about one or both of two axes perpendicular to each other and to the axis of the spin.

If when the wheel is spinning, a twisting force is applied about one of the two axes, it will produce a rotation, called precession, about the other axis.

It is used as a stabilizer of ships or airplanes or as a steering apparatus.

H

half-life

The length of time required for the decay of one-half of the atoms in a given sample of radioactive substance.

half moon

The colloquial term for the moon as seen in the phases known astronomically as the FIRST QUARTER and the LAST or THIRD QUARTER (q.v.).

half-thickness

In nuclear engineering, the thickness of a specified absorbing material which reduces the DOSE RATE (q.v.) to one-half of its original value.

Halley's Comet

Halley, an English astronomer, did not discover this comet. He first solved the problem of its motion and worked out its orbit, in 1705, and predicted its return in 1758. It did return and was named for him.

Its period is about 75 years, and there are records of every appearance, except one, since 240 B.C., altogether 28 returns.

Its last return was in 1910. It was discovered in Sept. 1909, became conspicuous in May 1910 and was followed until June 1911, when it was beyond the orbit of Jupiter. It goes out far beyond Neptune. It passed its aphelion point in 1945 and will be seen again in 1985.

In 1910 the head was as bright as the brightest stars, and

the tail was 50° long, about 40 million miles. On May 19, the head passed directly between the earth and the sun, but could not be seen even as a dark dot. Two days later the earth probably passed through the comet's tail, but nothing happened (*see* COLLISION). Halley's comet provides us with two meteor showers. The Eta Aquarids in May and the Orionids in October. Each of these showers lasts for about a week every year.

halos

Luminous rings around sun and moon. These are caused by refraction of light through ice crystals that form cirrus and cirro-stratus clouds, high above the earth's surface.

Halos are very similar to rainbows. They may show rainbow colors with the red inside, but are very often white.

The most common halo is a ring of 22° radius. Sometimes a larger ring of 46° radius is also seen. Rarely, bright spots, called "sun dogs" or "moon dogs," appear on the ring to the right and left of the sun or moon. Other variations are occasionally seen.

The idea that halos foretell storms has some basis in fact, for the high cirrus and cirro-stratus clouds often come before storms.

The corona of the sun is sometimes called a halo. (Cf. PLEOCHROIC HALO.)

hard radiation

see HARDNESS.

hardness

A relative term used to describe the penetrating quality of radiation. The higher the energy of the radiation, the harder (i.e., more penetrating) it is.

hardware

A colloquial military term for guided missiles, rockets, and weapons in general, their components and machinery.

harmonic law

Kepler's third law, as it is restated, now involves also the masses of the planets. It is now given this way:

The squares of the periods of any two planets, each multiplied by the sum of the sun's mass and the planet's mass, are in the same proportion as the cubes of their mean distances from the sun. (*see* KEPLER'S LAWS OF PLANETARY ORBITS.)

harvest moon

The full moon that occurs nearest to the autumnal equinox, Sept. 23. On the average, the moon rises about 50½ minutes later than it did the evening before. The full moon rises at sunset.

In September the moon is in that part of its orbit which is most nearly parallel to the horizon. So its point of rising moves northward rapidly, but its time of rising may be only a few minutes later each night. At 40° north latitude the difference may be only 13 minutes. Farther north it is less. Therefore there is moonlight early in the evening for an unusual number of evenings.

This is supposed to help farmers to work later in the harvest fields.

The next following full moon, in October, is the "hunter's moon."

This is only true in the northern hemisphere. In the southern one, the same conditions occur in March.

Hawk

U.S. Army missile.

haystack

The designation of the most commonly occurring form of the QUIESCENT SOLAR PROMINENCES (q.v.).

heading

In navigation and nautical astronomy, the direction in which the ship actually points or heads at any particular moment; it is the angle between the ship's keel and the meridian. Like

the COURSE (q.v.), it is measured in degrees from 0° at north, clockwise to 360°. Analogously, in aerial navigation, *heading* is the direction in which the aircraft is pointed.

health physicist

A specialist who is trained especially in radiation physics and concerns himself with problems of radiation damage and protection.

health physics

The science and technique of preventing radiation damage by proper protective and remedial measures.

heat index

The heat index of a star is the visual magnitude minus the radiometric magnitude as determined with the thermocouple.

heavenly body

see CELESTIAL BODY.

heavens

The space surrounding the earth. The sky.

In ancient cosmologies, the spaces or spheres in which the heavenly bodies revolved about the earth. Sometimes they meant the abodes of the gods or of departed spirits of men. The number of heavens varied from 7 to 11. Dante describes 9.

Heaviside layer

A layer of the IONOSPHERE (q.v.); being ionized, it reflects radio waves up to a frequency of 3000 kilocycles, thus making long-distance radio transmission and reception on earth possible. Also called *Heaviside-Kennelly layer and E layer. (see* APPLETON LAYER.)

heavy water

Water the molecule of which consists of the heavy hydrogen isotope of mass 2 (*deuterium* or *heavy hydrogen*), i.e., D_2O. (The term is occasionally applied also to water the deuterium content of which is greater than that of natural water.)

height of the earth's atmosphere

This can be computed from three different kinds of observations:

1. Meteors become visible when they are from 60 to 90 miles above the surface of the earth, and they cease to shine at 30 to 45 miles. This means that at 90 miles the air is dense enough to cause enough friction to heat the meteor to incandescence.

2. Aurorae have been photographed and measured up to 600 miles.

3. Duration of twilight. Twilight lasts until the sun is 18° below the horizon. By measuring the angular distance this is found to be about 50 miles. So the air, up where meteors and aurorae shine, is not dense enough to reflect the sunshine.

height of tide

Vertical distance from the surface of the water to the reference or datum plane from which tides are measured (*see* TIDES).

heliacal rising or setting

The rising or setting of a celestial body simultaneously with that of the sun; the reappearance of a celestial body after being made invisible by the rays of the sun, respectively its becoming invisible when overtaken by the sun and lost in its rays.

heliocentric

Viewed or considered from or referred to the sun as central point.

heliocentric latitude

Angular distance measured from the plane of the ecliptic.

heliocentric longitude

Angular distance measured from a plane that is perpendicular to the ecliptic and passes through the sun and the vernal equinox.

heliocentric parallax

see PARALLAX.

heliocentric position

The position of a body, expressed in terms of latitude and longitude, as it would appear viewed from the center of the sun.

heliocentric theory

The currently accepted view that the sun is the center of the solar system, and that the earth and the other planets revolve about it in elliptical orbits.

heliographic

Relating the sun, in particular to the solar surface and its description.

heliographic latitude

Angular distance on the sun north or south of its equator.

heliographic longitude

Angular distance east or west from a given point on the equator of the sun.

heliography

The study and description of the sun and its properties and characteristics.

heliometer

A telescope whose objective lens is divided through its center and so mounted that one half can be made to slide past the other.

It was designed to measure the diameter of the sun, but is useful in measuring small distances between stars or other celestial bodies.

helioscope

An instrument for the telescopic observation of the sun that provides protection to the eye of the observer from the glare.

helium

A chemical element, discovered in the spectrum of the prominences on the sun during the total solar eclipse of 1868. Its presence in some gas wells in Texas was not discovered until 1895.

Helium lines are prominent in spectra of the chromosphere and prominences, but are almost entirely absent in the dark-line solar spectrum.

helium-burning reactions

Those THERMONUCLEAR REACTIONS (q.v.), usually occurring in the central zones of giant stars, in which helium nuclei fuse to produce larger, heavier nuclei.

helium stars

The Class *B* stars (*see* SPECTRAL CLASSES), so named for the dominant lines in their spectra.

Hercules [the Kneeler]

A large constellation between Lyra and Corona with no stars brighter than 3rd magnitude. The brighter stars form a letter H.

It represents the strong man of ancient Greece who killed the Nemean Lion and always wears the lion's skin.

Near the west side of the H is a faint, fuzzy object, just visible to the naked eye, which is the globular cluster M13. It contains 50,000 stars each brighter than our sun, and is 34,000 light years away.

Alpha Herculis, named Ras Algethi, is a beautiful double, one star orange-red and the other blue-green. It is one of the largest stars ever measured, with a diameter 400 times that of our sun.

Hertzian waves

Radio waves which are very long, sometimes several miles in length.

Their position in the spectrum is far beyond the infrared and the heat waves.

Hesperus

The name given by the Greeks to the planet Venus when it was an evening star.

high tide

The highest level reached by an ascending tide. (*see* TIDES.)

high high tide

The high tides which occur near new or full moon. (*see* SPRING TIDES, TIDES.)

high low tides

The low tides which occur near the moon's first or third quarter. (*see* NEAP TIDES, TIDES.)

high velocity stars

Stars that are moving across the galactic track along which the majority of the stars execute their galactic rotation.

high water

see HIGH TIDE.

higher high water

The higher of the two high tides occurring at a place during a lunar day. (*see* TIDES.)

higher low water

The higher of the two low tides occurring at a place during a lunar day. (*see* TIDES.)

horizon

The line where the earth and the sky appear to meet. When used without a qualifying adjective or unless otherwise stated, this term usually denotes the VISIBLE HORIZON (q.v.).

horizon, celestial

The great circle of the celestial sphere, equidistant from the zenith and nadir. It is the intersection of the SENSIBLE and RATIONAL HORIZONS (q.v.) at infinity. Its plane passes through the center of the earth.

horizon, rational

Intersection of the celestial sphere and a plane through the center of the earth and perpendicular to the zenith-nadir line.

horizon, sensible

Intersection of the celestial sphere and a plane tangent to the earth at the observer.

horizon, terrestrial

The VISIBLE HORIZON (q.v.).

horizon, true

Another term for the RATIONAL HORIZON (q.v.).

horizon, visible

The line where the earth and the sky seem to meet as seen by an observer on earth.

horizon dip

see DIP OF THE HORIZON.

horizon distance

Multiply the height of the eye in feet by 3/2, and the square root of the product is the distance of the horizon in miles.

If a man stands at sea level with his eye 6 feet above the water, $6 \times 3/2 = 9$, and $\sqrt{9} = 3$, the horizon is 3 miles away.

If the man is on a hill, or climbs the mast of a ship so that he is 96 feet above the water, $96 \times 3/2 = 144$, and $\sqrt{144} = 12$ miles to horizon.

horizon-glass of a sextant

A small plane mirror fastened to the frame of the sextant in such position that when the vernier of the index reads zero, the index-mirror and the horizon-glass will be parallel to each other.

Only one half of the horizon-glass is silvered, the other half is clear, transparent glass.

horizon system of coordinates

A plane tangent to the earth at any point is projected until

it meets the celestial sphere. This is the horizon, or the fundamental circle of the system. The poles are the zenith and nadir. Vertical circles passing through the zenith and nadir and crossing the horizon at right angles are the secondary great circles. The vertical circle which passes through the poles of the earth is the meridian, which intersects the horizon at north and south points. The prime vertical is the vertical circle at right angles to the meridian, and intersects the horizon east and west. Coordinates are not constant since altitude and azimuth constantly change due to diurnal rotation. The horizon system is local and observations depend upon position of the observer.

horizontal level

Parallel to the horizon.

horizontal parallax

The parallax of a celestial body seen in the horizon, when parallax has its maximum value.

Horologium [the Clock]

A southern constellation.

horsepower of the sun's radiation

The energy radiated by the sun and received by the earth is equal to 1½ horsepower for every square yard of the earth's surface. Calculating from this the number of square yards in the surface of a sphere whose radius is the distance of the earth from the sun, we can get the total radiation of the sun, as 5.08×10^{23} horsepower.

Dividing this total by the number of square yards in the sun's surface, we find that each square yard emits continually an amount of energy equivalent to 70,000 horsepower.

hot

In nuclear engineering, a widely used colloquial term meaning "highly radioactive."

hot atom chemistry

The study and application of the chemical reactions and properties of atoms that are radioactive or in a high state of excitation or have acquired high kinetic energy as a result of nuclear processes (referred to as *hot atoms*).

hour

One twenty-fourth of a day. It is an arbitrary division of time. No one seems to know when or by whom the division into 24 hours was made. Until the 18th century the hour was commonly reckoned as 1/12 of the time between sunrise and sunset, or between sunset and sunrise.

This means that hours were of unequal lengths in the summer and in the winter. When clocks began to be used, and this was inconvenient, they were made equal.

hour angle

The angular distance measured westward along the celestial equator from the upper branch of the celestial meridian to the hour circle of the star. It can be found by subtracting the the star's right ascension from the sidereal time. (Cf. SIDEREAL HOUR ANGLE.)

hour circle

A great circle of the celestial sphere passing through the celestial poles and a celestial body or the vernal equinox. An hour circle moves with the body as the celestial sphere rotates, unlike the celestial meridian of a point which remains fixed.

hour circle of a telescope

A graduated circle fixed to the polar axis of the telescope, showing the hour angle of the star toward which the instrument is pointing.

By using this and the DECLINATION CIRCLE (q.v.) the telescope can be pointed toward any object whose right ascension and declination are known.

Hunter's moon

The next full moon after the Harvest moon, usually in October.

Because the full moon is not far from the autumnal equinox, its orbit is inclined only a little to the horizon, and it rises more nearly at the same time than it does in other months. There is moonlight in the evenings for several nights.

In March, at the time of the vernal equinox, conditions are reversed and the full moon may rise as much as 1 hr. 20 min. later from night to night.

In the southern hemisphere the harvest moon comes in March and the hunter's moon in April.

Huyghenian eyepiece

A NEGATIVE EYEPIECE (q.v.).

Hyades

An open cluster of about 140 stars the brightest of which form the V shaped figure in the face of Taurus, the Bull.

The cluster is spheroidal, about 58 light years in diameter and 130 light years from the sun. The stars are all moving toward a point a little way east of Betelgeuse in Orion.

The bright star Aldebaran is in the cluster but is not a part of it.

Hydra [the Water Snake]

The longest of all the constellations.

A line of faint stars beginning a little south and west of Leo and extending past Spica in Virgo. It contains only one 2d magnitude star.

It represents the huge snake with 9 (some said 50 and 100) heads, that was slain by Hercules as the second of his 12 labors.

The brightest star, Alphard, is much larger and brighter than the sun, but is 815 light years away.

The two small constellations CRATER (q.v.) and CORVUS (q.v.) stand on the back of Hydra.

hydrazine hydrate

Fuel using nitric acid as oxidizer, but not requiring special detonator.

hydrocarbons in comets

see CYANOGEN IN COMETS.

hydrogen

The lightest of the chemical elements, and the most abundant element in the sun.

Symbol H, atomic weight 1; its atom is composed of one proton and one electron.

hydrogen-burning reactions

Those THERMONUCLEAR REACTIONS (q.v.), usually occurring in the outer regions of the giant stars, in which hydrogen nuclei fuse to produce helium nuclei. (*see* CARBON CYCLE.)

hydrogen stars

The Class *A* stars (*see* SPECTRAL CLASSES), so named for the dominant lines in their spectra.

hyperbola

The curve formed when a right, circular cone is cut by a plane at a greater angle with the base than the side of the cone makes.

It is an open curve with only one focus.

The orbits of some comets may be hyperbolic. (*see* CONIC SECTIONS.)

hyperbolic orbits

It was formerly believed that the orbits of many comets were parabolic, and that some were hyperbolic. If this were so, it would mean that these comets were not permanent members of the solar system, but they came from among the stars, passed once near the sun and went away never to return.

For the very small part of the orbit that can be observed, the difference between an ellipse, a parabola and a hyperbola, is very difficult to calculate. It is now believed that all comets move in ellipses, which are closed curves and none move in open orbits which would be parabolic or hyperbolic.

There seem to be some meteors that come in from outer space, possibly on hyperbolic paths, but that is not certainly proved.

Hyperion

A satellite of Saturn. (*see* SATELLITES OF THE SOLAR SYSTEM.)

hypersonic speed

Any speed that is five or more times the velocity of sound (760 m.p.h. at normal sea-level conditions).

hypothesis of dynamic encounter

The PLANETESIMAL HYPOTHESIS and the TIDAL THEORY of the solar system (q.v.).

I

Iapetus

A satellite of Saturn. (*see* SATELLITES OF THE SOLAR SYSTEM.)

ICBM

The abbreviation for INTERCONTINENTAL BALLISTIC MISSILE (q.v.).

IGY

The abbreviation for INTERNATIONAL GEOPHYSICAL YEAR (q.v.).

illuminometer

An instrument for measuring the intensity of light.

The standard of illumination is the candlepower. Each square inch of the sun's surface is shining with the intensity of 300,000 candles.

image

The potential reproduction of a point or object, produced in an optical instrument by a lens or mirror.

image stop

A round blackened cardboard disk or a disk of other suitable material with a hole in its center, the radius of the hole being equal to the radius of the image formed by the objective of a telescope; it is inserted into the focal plane of the telescope to produce a sharp image by eliminating the faint rays at the edges and scattered light.

immersion

The disappearance of a celestial body, either by passing behind another, as when a star is occulted by the moon or a planet; or by passing into its shadow, as in an eclipse of a moon.

inclination of planetary equators

The angle between the plane of the equator of the planet and the plane of its orbit:

Mercury—unknown	Saturn 26° 45′
Venus—unknown	Uranus 97° 59′
Earth 23° 27′	Neptune 29°
Mars 25° 12′	Pluto—unknown
Jupiter 3° 7′	

inclination of planetary orbits

The angle between the plane of the orbit and the plane of the ecliptic, which is the plane of the earth's orbit.

The inclinations of the planetary orbits are:

Mercury 7° 0′	Jupiter 1° 18′
Venus 3° 24′	Saturn 2° 29′
Earth 0° 0′	Uranus 0° 46′
Mars 1° 51′	Neptune 1° 47′
Ceres 10° 37′	Pluto 17° 9′

index

An indicator of the relation of a phenomenon to another, expressed usually numerically.

index arm of a sextant

A solid metal arm, pivoted at the center of the arc, above which the index mirror is fixed, and having at its other end a vernier which slides along the arc. It can be fixed at any point by a clamp, and moved through very small distances by a delicate screw.

The reading of the vernier gives the angle measured by the instrument.

index correction

The reading of the sextant, with reversed sign, when an angle of 0° is observed. It may be either plus or minus, and is a property of individual sextants. It is essentially constant for all altitudes, and applies to all celestial bodies. (Cf. INDEX ERROR.)

index error

The error in the reading of a mathematical instrument equal to the difference between the zero of the index and the zero of the limb.

index mirror of a sextant

A plane mirror, about 1¼ × 2 inches in size, fastened to the index arm at the center of motion and perpendicular to the plane of the arc.

It catches the light of the sun or a star, reflects it to the horizon-glass, which thus reflects it through the telescope to the eye of the observer.

index of refraction

A measure of refracting power.

The ratio of the velocity of light in two different media.

It varies with the media, temperature, pressure, etc., and with the wavelength of the light.

indicator

Piece of electronic equipment which presents information in visual form. The principal element is a cathode ray tube. (*see* OSCILLOSCOPE.)

Indus [the Indian]

A southern constellation.

inequality

A term used in mathematical astronomy to mean irregularity in the motion of a planet.

inert gases

Gases that are chemically inactive and do not easily combine

with others. They are helium, neon, argon, krypton and xenon. Sometimes thoron, radon and actinon are included. They are called also *rare gases.*

inertia, inertial force

The natural tendency of every body to remain in its existing condition of rest or motion, i.e., its resistance to any change in its state of rest or motion—the resistance to being set in motion or stopped, to every acceleration or deceleration. The force with which a body offers such resistance is called the *force of inertia.*

inertial guidance system

A system of guidance of missiles and unmanned rockets and other research craft and vehicles through a great many delicate instruments, carried within the missile or vehicle, which monitor and interpret electronically every element of aspect of flight and make every necessary correction automatically to conform with a predetermined flight plan.

inferior conjunction

The condition existing when a celestial body is between the earth and the sun, so that both the body and the sun, as seen from the earth, have the same celestial longitude.

inferior planet

A planet that circles the sun in an orbit smaller than the Earth's. The inferior planets of our solar system are· Mercury and Venus.

infinity of the universe

Infinity means being without end. Moulton and many other astronomers believe that the universe is infinite. Certainly an end to it has never yet been found. Larger telescopes simply see farther, and reveal more galaxies at greater distances.

Some scientists believing that space is curved, imagine a finite limit, but they can not prove its existence.

infrared radiation

Electromagnetic radiation beyond the red end of the visible spectrum, in the band of wavelengths between approximately 0.75 micron and 1000 microns (1 millimeter); it includes the entire range of radiant heat waves.

inner metagalaxy

The nearest regions of the METAGALAXY (q.v.).

inner planets

The four planets nearest to the Sun: Mercury, Venus, Earth and Mars.

insolation

The solar radiation received by the earth.

The daily amount of energy received depends on the season and the length of the day.

In winter, when the sun is low in the south and the day is short, we get much less sunshine than in summer with the sun high and the day long.

At the summer solstice the sun is higher at noon in New York than it is at the equator, and it is visible for a longer time, so that the amount of heat delivered is 25% greater. Even at the north pole at that time the daily insolation is nearly the same as that at the equator. Twenty-four hours of sunshine makes up for the lower altitude of the sun.

instrumental error

An error in the reading of an instrument caused by an imperfection or imperfections of the instrument itself. (When the imperfection is in the graduations on its scale, the error is called specifically a *scale error*.)

instrumentation

The art and technique of designing, installing and using precision instruments; also the precision instruments provided.

intensity of a beam

The FLUX DENSITY (q.v.).

intercept

Cf. ALTITUDE DIFFERENCE.

intercontinental ballistic missile (ICBM)

A guided missile of a ballistic nature, capable of at least 5000 miles of travel in a partially controlled trajectory, and suitable for launching artificial satellites.

interference fringes

The alternate light and dark bands that are seen when two beams of homogeneous light enter into INTERFERENCE (q.v.) with each other, i.e., when they overlap and illuminate an identical area.

interference of light

When two beams of light from the same source, but arriving by different paths, meet, their waves will amplify each other at some points and cancel each other at other points, giving a series of light and dark lines, bands or fingers.

If the two beams are of white light the bands or *fringes* will show rainbow colors.

When the two beams of light meet so that the wave crests in one coincide with the wave crests in the other, they reinforce each other, and we speak of *constructive interference;* when crests coincide with troughs, the two beams cancel each other out, and the phenomenon is referred to as *destructive interference.*

interferometer

In general, any instrument designed for producing and studying interference of two or more trains of waves or beams of electromagnetic radiation of the same range of wavelengths. Unless otherwise stated, the term is usually employed to denote an *optical interferometer,* i.e., an instrument that separates a beam of light into two (or more) parts which are made to travel different optical paths and are then reunited to produce INTERFERENCE FRINGES (q.v.). The various versions of this instrument (*see* BEAM INTERFEROMETER, STELLAR IN-

TERFEROMETER) are used in astronomy for measuring the separations and position angles of double stars and the diameters of giant stars. Analogous instruments have been developed in radio astronomy (*see* RADIO INTERFEROMETERS).

intergalactic space

That part of space conceived as having its lower limit at the upper limit of INTERSTELLAR SPACE, and extending to the limits of space.

interior of a star

It is believed that all stars are perfect gases, but due to their great sizes and therefore varying gravitation, the densities in their interior will vary greatly.

The density in the outer part of a giant star like Betelgeuse, must approach that of a vacuum, but toward the center the density will be very great.

In white dwarf stars the density is many tons to the cubic inch.

Radiation flows from the interior of the star to the surface, and so keeps the star shining.

Temperature, like density, increases from the surface to the center, where it may be millions of degrees.

intermediate range ballistic missile (IRBM)

A guided missile of a ballistic nature, capable of traveling about 1500 miles in a partially controlled trajectory, and suitable for launching artificial satellites.

internal heat of the Earth

Hot springs, geysers and volcanoes prove that the interior of the earth is hotter than the surface.

The rate of increase of temperature with depth is not constant, but it is about 1°F per 75 feet.

If this increase were constant, at a depth of 62 miles it would be 4500°F, and half way to the center of the earth it would be 292,500°F. This would be hot enough to melt and vaporize any known substance.

Lava from volcanoes is supposed to come from a depth of something like 30 miles.

international date line

A line designated by international agreement, coinciding approximately with the 180th meridian; on the opposite sides of this line the date differs by one day. The date east of the international date line is one day later than west of it; the time on both sides of the line is the same. Ships sailing westward set their calendars forward one day, those sailing eastward set it back one day as they cross the line.

International Geophysical Year (IGY)

A program of cooperative study of all earth sciences and all factors and elements that shape or in any manner pertain to the common physical environment of mankind. All scientific data acquired during this program (July 1957-January 1959) are to be shared by all participating nations which number more than fifty.

interplanetary

Between the planets; within the solar system.

interplanetary atmosphere

Scientists cooperating in the International Geophysical Year (IGY) announced in 1957 that there is apparently some kind of atmosphere, even though very sparse, throughout the solar system, which may be an extension of the CORONA OF THE SUN (q.v.).

interplanetary space

That part of space conceived, from the standpoint of the earth, to have its lower limit at the upper limit of TRANSLUNAR SPACE, and extending to beyond the limits of the solar system, some several billion miles.

interpretational astronomy

That branch of ASTRONOMY (q.v.) which endeavors to make astronomical principles and accomplishments understandable

to the general lay public. Public observatories, planetariums, amateur astronomical societies, radio and television programs and the press have contributed to the growing public interest in astronomy.

interstellar

Between or among the stars.

interstellar lines

Certain narrow dark lines in the spectra of stars, which are produced by a tenuous, gaseous medium in space. This is supposed to be immense clouds of gas or dust in space between the stars.

The lines have been identified with calcium, sodium, potassium and titanium.

interstellar material

Tenuous gas and dust present in the arms of the galactic system.

interstellar space

That part of space conceived as having its lower limit at the upper limit of INTERPLANETARY SPACE, and extending to the lower limits of INTERGALACTIC SPACE.

intra-Mercurial planet

A hypothetical planet circling the sun in an orbit within that of Mercury. Leverrier, after his discovery of Neptune in 1846, studied the motion of Mercury and concluded that some of the variations were caused by another planet between Mercury and the sun. He named the supposed planet *Vulcan.*

This planet has never been seen. Evidently it does not exist.

Many photographs have been made during total eclipse of the sun. They would show any object as large as 40 miles in diameter, but they never have.

intrinsic stellar variability

Change in the brightness of a star owing to some cause

other than eclipse by a companion or obscuration by interstellar clouds.

intrinsic variable stars

Stars that are variable naturally, not owing to eclipses. This classification includes the IRREGULAR VARIABLES, NOVAE and the PULSATING STARS (qq.v.).

invar

A nickel-steel alloy which is the best known material for the pendulum of a clock, because its coefficient of expansion is very small, almost zero.

invariable plane

A plane passing through the center of gravity of the entire solar system maintains its direction in space exactly invariable.

This plane is inclined 1°35′8″ to the ecliptic. It is between the planes of the orbits of Jupiter and Saturn, but nearer to Jupiter's.

inverse Mercator projection

Representation of part of the earth's surface by development on a cylinder tangent at a meridian, used principally for polar navigation where distortion is slight. Meridians are sinusoidal lines and parallels of latitude are ovals.

inverse square law

The amount of light, or heat, received by a planet varies inversely as the square of its distance from the sun.

Pluto, 40 times as far out as the earth, must receive only 1/1600 as much heat and light per unit area of surface as the earth receives.

That is why the planet was named Pluto for the god of darkness.

inversion of temperature

see TEMPERATURE INVERSION

Io

A satellite of Jupiter. (*see* SATELLITES OF THE SOLAR SYSTEM.)

ion

An electrified particle formed when an atom loses or gains one or more electrons.

If it loses an electron, it becomes positively electrified.

If it gains an electron, it becomes negatively electrified.

A *singly ionized atom* has lost only one electron. A *doubly ionized atom* has lost two electrons, and so on. As many as seven electrons have been removed from an atom of chlorine.

ion pair

A positively charged atom (ion) and an electron formed by the action of radiation upon a neutral atom.

ion rocket

(ASTRONAUTICS) A proposed rocket that would be propelled by the thrust furnished by the recoil of the ejection at high velocities of streams of electrically charged particles.

ionization

The process whereby one or more electrons are removed from a neutral atom by the action of radiation. SPECIFIC IONIZATION is the number of ion pairs (q.v.) per unit distance in matter, usually air.

Low pressures and high temperatures cause ionization in gases in the atmosphere of stars.

The very high temperature in the interior of a star is supposed to ionize completely the atoms of which it is composed.

ionization of a gas

A gas is ionized when a relatively small number of its atoms are converted into ions. The gas then becomes an electrical conductor.

Because of the very high temperatures of the stars, much of the gas in their atmosphere is ionized.

ionization potential

A number of electron volts that is proportional to the total energy require' to remove an electron from a neutral (or already ionized) atom.

ionized atom

An atom that has lost one or more electrons. (*see* ATOM.)

An atom that has lost one electron is said to be singly ionized. It is designated by a + sign thus Si^{+}. If it has lost two electrons it is doubly ionized, Si^{++}. If three it is triply ionized Si^{+++}, and so on. Hence an atom with a net positive charge.

ionizing radiation

Electromagnetic radiation (alpha or beta particles, gamma or x-rays, or neutrons) that produces ions as it passes through a substance (In radiation physics, through human or animal tissue).

ionosphere

That region of the ATMOSPHERE OF THE EARTH (q.v.) which extends from the upper limits of the STRATOSPHERE to the EXOSPHERE (q.v.), i.e., to an altitude of approximately 500 miles above ground. It is so named because it is a region of ionization of atoms, and its ionized layers reflect radio waves and short-wave communication waves, thus making radio and short-wave transmission possible over long distances (*see* HEAVISIDE LAYER and APPLETON LAYER).

ionospheric absorption

Radio waves, of the longer wavelengths, suffer severe absorption in the lower portions of the ionosphere.

The variations of this absorption seem to follow the sunspot cycle.

IRBM

The abbreviation for INTERMEDIATE RANGE BALLISTIC MISSILE (q.v.).

Iris

A solid-propellant research missile, designed to lift a payload of 100 lbs. to an altitude of approximately 200 miles.

irradiation

The exposure to radiation.

irregular galaxies

A small group (about 5%) of EXTERNAL GALAXIES (q.v.) which show no definitely discernible shape or order, except that most of them have a flattened appearance. They contain large clouds of gas.

irregular variable

A variable star with no fixed period. The stars so designated are very diverse in character and include some semiperiodic stars such as Betelgeuse (α Orionis) which brighten suddenly two or three magnitudes and then fade gradually, as well as others that remain at a fairly constant brightness, suddenly fade several magnitudes and vary irregularly until they regain their ordinary brightness. (In the case of Betelgeuse, the radial velocities, the apparent angular diameter and the light changes seem to vary together.) All these stars (a few dozens altogether) appear to be GIANTS or SUPERGIANTS, but some apparently belong in the MAIN SEQUENCE (q.v.); these are usually found associated with an obscuring nebulosity.

island universe

The formerly current term for an EXTERNAL GALAXY (q.v.).

iso-

A prefix (becoming *is-* before a vowel) of Greek origin, meaning "equal," used to denote equal quantity or intensity. It should be used only as a prefix to words of Greek origin; the proper prefix to words of Latin origin is *equi-*.

isogonic lines

Lines drawn through points on earth which have the same magnetic variation or declination. (*see* TERRESTRIAL MAGNETISM.)

isophote

A line of equal intensity of light. Used in the study of the corona of the sun.

isostasy

General equilibrium in the earth's crust supposed to be maintained by the yielding or flow of rock material beneath the surface under gravitational stress.

By the theory, each unit column of the earth, from surface to center, has approximately the same weight, and the continents stand higher than the ocean beds because they are made of less dense material.

isotopes

Atoms of the same element which differ from each other by having different weight. Being chemically identical varieties of the same element, they have the same atomic number (same number of protons in the nucleus) but different mass numbers (different number of neutrons in the nucleus). The chemical symbols of isotopes therefore consist of the same letter or pair of letters denoting the element, preceded by the same atomic number as a prefix and followed by different mass numbers as superscripts (e.g. $_6C^{11}$, $_6C^{12}$, $_6C^{13}$ and $_6C^{14}$ are the symbols of four different isotopes of the element carbon) (C).

J

jets

Geyserlike eruptions on the sun, causing prominences that rise from 25,000 to 50,000 miles, or higher.

Jewish calendar

see CALENDAR.

Julian Calendar

The calendar as ordered by Julius Caesar, consisting of the present twelve months and the leap year day. It was first used in 44 B.C.

This calendar was used for over 1600 years. The year was 11 minutes 14 seconds too long.

For the next reform *see* GREGORIAN CALENDAR.

Julian Day

see DAY.

Jupiter

The largest of all the planets, and usually brighter than any planet except Venus and occasionally Mars.

Mean distance from the sun 483,200,000 miles or 5.203 times the distance of the earth.

Diameter 88,640 miles, 11 times that of the earth.

Period of revolution 11.862 years, nearly 12.

Period of rotation 9 hr. 50 min.

Mass 316.94 times that of the earth.

Density 1.34 imes that of water.

Surface gravity 2.64 times that of the earth. A man who weighs 150 pounds on earth would weigh 396 pounds on Jupiter.

Jupiter is not only the largest planet, but is much larger than all the others combined.

Jupiter has the shortest day of any planet. The speed of rotation at the equator is 27 times that of the earth.

This high speed of rotation causes much flattening at the poles. Its polar diameter is 5,909 miles, that is, 1/15 less than its equatorial one.

The surface of the planet is obscured by heavy belts of clouds parallel to its equator.

The equator is inclined only 3°7′ to the plane of its orbit, which means that it could have almost no seasons.

Jupiter has an extensive atmosphere made up very largely of methane and ammonia gases. The clouds are probably crystals of frozen ammonia. If there is any water there, it is solid ice.

The planet is so far from the sun that its temperature is very low. The maximum is —216 F.

Jupiter has 12 satellites or moons. Four are large and were the first celestial bodies discovered with a telescope. They are called the GALILEAN SATELLITES (q.v.). The other eight are very small. The fifth satellite, which is nearest the planet, revolves in a little less than 12 hours. The eighth, ninth and eleventh have a retrograde revolution, opposite to the motion of the planet. The outer satellites are so small and so far away that they would be invisible to the naked eye from the surface of the planet. The combined light of all the satellites on the surface of the planet is not more than one third of the light of the full moon upon the earth.

From the motion of Jupiter's satellites, Roemer, a Danish astronomer, in 1675 discovered and measured the finite velocity of light.

Jupiter

An intermediate-range (1500 miles) liquid-propellant surface-to-surface ballistic rocket of the U.S. Army. Overall length almost 70 feet, body diameter slightly less than 6 feet; take-off weight about 40,000 lbs., thrust 65,000 lbs., velocity Mach 15. A four-stage Jupiter C was used to launch the first artificial earth satellite of the U.S., EXPLORER I (q.v.).

Jupiter's family of comets

About 40 of the 100 comets having comparatively small elliptical orbits belong to Jupiter's family. Their aphelion points are near to Jupiter's orbit, and most of them come very near to that planet. They are all small, inconspicuous comets.

K

K corona

The inner portion of the CORONA (q.v.) of the sun.

K temperature

Abbreviation for Kelvin temperature. (*see* ABSOLUTE TEMPERATURE

kamacite

A nickel-iron alloy forming with taenite the mass of most meteoric iron.

Kapteyn selected areas

The areas of our galaxy on which J. C. Kapteyn suggested that the various methods of studying stellar magnitudes, motions, etc. be concentrated in order to determine the structure of the galaxy.

Kapteyn universe

In 1922 Kapteyn, a Dutch astronomer, gave us the best idea we have of our GALAXY (q.v.) of stars. He said it is a vast cluster of stars, in the form of a flattened ellipsoid of revolution. Its diameter is about five times its thickness. The stars are closest together at the center, and thin out toward the edges, with no definite boundary. He estimates the whole number of stars at 47 billions.

This is only a generalized picture, giving no details. Kapteyn did not live to finish his investigations.

Kellner eyepiece

A POSITIVE EYEPIECE (q.v.) consisting of a plano-convex FIELD-LENS (q.v.) and a likewise plano-convex achromatic EYE LENS (q.v.), the convex surfaces of which face each other.

Kelvin scale, Kelvin temperature

see ABSOLUTE TEMPERATURE, ABSOLUTE ZERO.

Kennelly-Heaviside Layer

see IONOSPHERE.

Kepler's laws of planetary motions and orbits

Laws governing the motions of planets in their orbits, discovered by Johannes Kepler.

1. The orbits of the planets are ellipses, with the sun at a common focus.

2. The line joining a planet and the sun sweeps over equal areas during equal intervals of time.

3. The squares of the periods of revolution of any two planets are proportional to the cubes of their mean distances from the sun. (Cf. HARMONIC LAW.)

Kepler's Star

The second brightest nova ever recorded. It appeared in Ophiuchus, in October 1604, became as bright as Jupiter, and was visible to the naked eye for 18 months, until March 1606.

kiloparsec

A distance of 1000 parsecs or 3,260 light years.

Used in some measurements of the distances of external galaxies and globular clusters.

kinetic energy

The energy that a moving body has on account of its motion. It is equal to one half the mass times the square of the velocity, $E = \frac{1}{2}mv^2$.

kinetic theory of gases

A theory concerned with the movements of the molecules of gases.

It says that they obey the laws of kinetic energy which means that $E = \frac{1}{2}mv^2$ where E is the molecular energy, m is the mass and v the velocity of the molecule.

This is important in relation to the atmosphere of the earth and other planets. (*see* VELOCITY OF ESCAPE.)

Kirchhoff's laws of spectra

1. Light from an incandescent solid or liquid, or a dense gas, gives a continuous spectrum, a band of colors from red to violet.

2. Light from a glowing, rarified gas, composed of atoms of elementary chemical substances, gives a spectrum of bright lines on a dark background.

3. When light from a solid, liquid or dense gas, passes through a comparatively cool gas, (which would, by itself, give a bright line spectrum) the continuous band of color is crossed by dark lines that correspond exactly to the bright lines that the gas is capable of emitting.

Kirkwood gaps

Regions or belts in the main zone of ASTEROIDS (q.v.) where practically no asteroids are found; these are the areas movement in which would require an asteroid to have a period equal to a simple fraction of Jupiter's period, which evidently no asteroid can have.

knot

Unit of speed equal to one nautical mile per hour.

L

Lacrosse

A short-range (9-10 miles) guided, solid propellant-powered, surface-to-surface missile of the U.S. Army.

lag of the seasons

According to the calendar, spring and autumn begin at the equinoxes, and the solstices mark midsummer and midwinter. But according to the climate, the hottest weather comes in late July or August, and the coldest weather near the first of February.

This is because the earth does not radiate heat immediately after it is received. After March 21, the day is longer than the night. More heat is received than is radiated, and the excess is stored in the earth and the water, and the weather continues to grow warmer until after the longest day.

The reverse is true after the autumnal equinox, when the nights become longer than the days.

lagging of the tides

Delay in tides when the tides caused by the sun come shortly after those caused by the moon. (*see* TIDES.)

lambert

A unit of brightness of an extended surface.

It is the brightness of a shining surface which is emitting one lumen per square centimeter.

The Circumpolar Constellations Northern Hemisphere

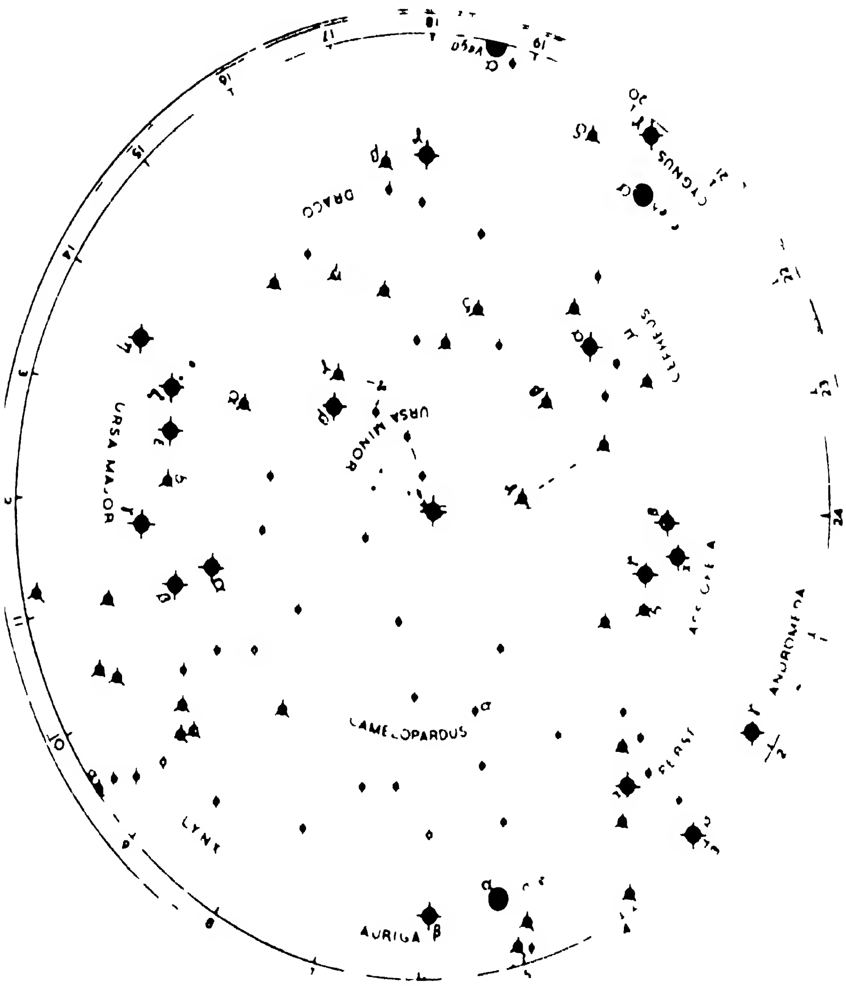


PLATE I

1 Angstrom unit	$= 10^{-8}$ cm.	
1 micron	$= 10^{-4}$ cm $= 0.001$ mm.	
1 centimeter	$= 0.3937$ inch	
1 inch	$= 2.54$ centimeters	
1 meter	$= 10^2$ cm $= 3.28084$ feet	
1 kilometer	$= 10^5$ cm $= 0.62137$ miles	
1 mile	$= 1.60935 \times 10^5$ cm $= 1.60935$ km $= 5280$ feet	
1 astronomical unit	$= 1.49678 \times 10^{13}$ cm $= 93,005,000$ miles	
1 light-year	$= 9.463 \times 10^{17}$ cm $= 5.880 \times 10^{12}$ miles $= 63,300$ astron. units	

UNITS OF TIME

Sidereal day $= 23h\ 56m\ 04.09s$ of mean solar time
Mean solar day $= 86400$ seconds
Synodical month $= 29d\ 12h\ 44m$, sidereal month $= 27d\ 07h\ 43m$
Tropical year (ordinary) $= 365d\ 05h\ 48m\ 46s = 31,556,926$ seconds
Sidereal year $= 365d\ 06h\ 09m\ 10s = 31,558,150$ seconds
Eclipse year $= 346d\ 14h\ 53m$

THE EARTH

Equatorial radius, $a = 3963.35$ miles
Polar radius, $b = 3950.01$ miles, flattening $c = (a - b)/a = 1/297.0$
Acceleration due to gravity, $g = 32.17$ ft/sec/sec $= 981$ cm/sec/sec (in latitude 45°)
Mass of Earth $= 6.6 \times 10^{21}$ tons, velocity of escape from Earth $= 6.94$ miles/sec.

EARTH'S ORBITAL MOTION

Solar parallax $= 8''.79$, constant of aberration $= 20''.47$
Annual general precession $= 50''.26$, obliquity of ecliptic $= 23°\ 26'\ 50''$ (1939)
Orbital velocity $= 18.5$ miles/sec
$= 29.8$ km/sec, parabolic velocity at Earth $= 26.2$ miles/sec

SOLAR MOTION

Solar apex R.A. $18h\ 04m$, Dec. $+31°$
Speed relative to neighboring stars $= 12.2$ miles/sec $= 20$ km/sec

THE GALACTIC SYSTEM

North pole of galactic plane R.A. $12h\ 40m$, Dec. $+28°$ (1900)
Center $325°$ galactic longitude, R.A. $17h\ 24m$, Dec. $-30°$
Distance to center $= 30,000$ light years, diameter $= 100,000$ light years
Rotational velocity (at Sun) $= 262$ km/sec
Rotational period (at Sun) $= 2.2 \times 10^8$ years
Mass $= 2 \times 10^{11}$ solar masses

RADIATION CONSTANTS

Velocity of light $= 299,774$ km/sec $= 186,271$ miles/sec
Solar constant $= 1.93$ gram calories/square cm/minute
Light ratio for one magnitude $= 2.512$, log ratio $= 0.4000$
Radiation from a star of zero apparent magnitude $= 3 \times 10^{-6}$ meter candles
Total energy emitted by a star of zero absolute magnitude $= 5 \times 10^{25}$ horsepower

MISCELLANEOUS

Constant of gravitation, $G = 6.670 \times 10^{-8}$ c.g.s. units
Mass of the electron, $m = 9.035 \times 10^{-28}$ gm., mass of the proton $= 1.662 \times 10$

1 radian $= 57°.2958$	$\pi = 3.141,592,653,6$
$= 3437'.75$	No. of square degrees in the sky
$= 206,265''$	$= 41,253$

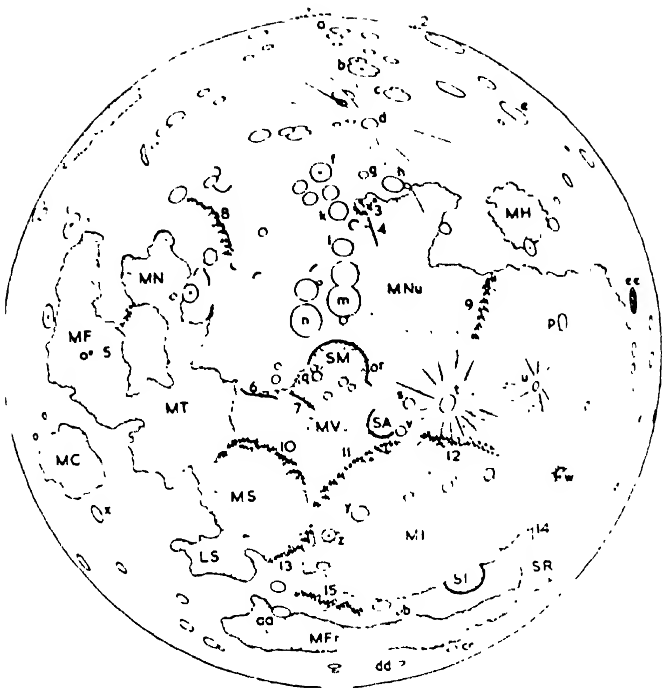
PLATE II

THE CONSTELLATIONS

Name	Genitive	Abbreviation[a]	Name	Genitive	Abbreviation[a]
Andromeda	Andromedae	And	L[illegible] rta	Lacertae	La
Antlia[b]	Antliae	Ant	Le	Le[illegible]	Leo
Apus	Apodis	Aps	L[illegible] Minor	Le[illegible] Minoris	LMi
A[illegible]arius	A[illegible]uarii	Aq	Le	L[illegible]	Lep
Aquila	Aquilae	Aql	Li[illegible]	L[illegible]	Lib
Ara	Arae	A[illegible]	L	L	Lup
Arg[illegible] Navis)	Argus		Ly	L[illegible]	Lyn
Aries	Arietis	[illegible]	L	Lyrae	Lyr
A[illegible]ga	A[illegible]	A[illegible]	Me	Me[illegible]	Men
[illegible]otes	B[illegible]	B	M[illegible]	[illegible]	Mi
[illegible]elum	Caeli	C	M[illegible]	[illegible]	M
[illegible]amel[illegible]ardalis	Camel[illegible]	C	M	[illegible]	Mus
[illegible]ancer	C[illegible]		N[illegible]	N[illegible]	Nor
[illegible]anes Venatici	C[illegible] Venat[illegible]	CV	O[illegible]	O[illegible]	Oc
[illegible]anis Major	C[illegible] Majoris	CM	O[illegible]	O	Oph
[illegible]anis Minor	Canis Min[illegible]	CM	Or	O[illegible]	Ori
[illegible]pric[illegible]rnus	Capr[illegible]	C	Pav[illegible]	Pav[illegible]	Pav
[illegible]ssi[illegible]peia	Cassi[illegible]	C	Peg	Peg[illegible]	Peg
[illegible]entaurus	Centa[illegible]	C	Pe	Pe	Per
[illegible]phe[illegible]	Cephei	Ce	P	P	Phe
[illegible]tus	Ceti	C	P	P	Pic
[illegible]amaele[illegible]	Ch[illegible]aele[illegible]	C	P	P	Ps
[illegible]ius	C[illegible]	C	P[illegible]A	P[illegible]A	PsA
[illegible]mba	C[illegible]	C	P	P	Pu
[illegible] Berenices	C[illegible]	C	[illegible]	R	Re
[illegible] A[illegible]	C[illegible] A	C	S[illegible]	S[illegible]	Sge
[illegible] Borealis	C[illegible] Bor[illegible]	CB	S[illegible]	S[illegible]	Sgr
[illegible]vus	C[illegible]	C	S	S	Sc
[illegible]er	Crateris	C	S	S	Sc
[illegible]	C[illegible]	C	S[illegible]	S[illegible]	S
[illegible]gnu[illegible]	C[illegible]	C	S[illegible]	S[illegible]ati	Sc
[illegible]lph[illegible]	Delph[illegible]	De	Se[illegible]	Serp	Se
[illegible]do	D[illegible]	D	Sex	Sextantis	Sex
[illegible]	Dra[illegible]	D	T	T[illegible]	T
[illegible]le	E[illegible]	E	T	T[illegible]	Te
[illegible]an[illegible]	Erid[illegible]		T[illegible]	T[illegible]	T
[illegible]nax	F[illegible]	F	T[illegible] A[illegible]	T[illegible] A[illegible]	TrA
[illegible]mini	Gemin[illegible]	Ge	T[illegible]	T[illegible]	Tu
[illegible]s[b]	Gruis	G	Ursa Ma[illegible]	U[illegible] M[illegible]	UMa
[illegible]les	Herculis	H	U[illegible] Mi[illegible]	Ursae [illegible]	UMi
[illegible]ologium[b]	H[illegible]	H[illegible]	V[illegible]		V
[illegible]	Hydrae	Hya	[illegible]	V[illegible]	V
[illegible]rus	Hydri	Hy	V[illegible]	V[illegible]ae	V
[illegible]	Ind[illegible]	I			

[a] [illegible] by the Inte[illegible] A[illegible]
[b] [illegible]
[c] [illegible] constellati[illegible] [illegible] Vela

The Moon



CRATERS: *a.* Newton; *b.* Clavius (interior detail); *c.* Longomontanus; *d.* Tycho (with rays); *e.* Schickard (detail); *f.* Walter; *g.* Hell; *h.* Pitatus; *i.* Petavius; *k.* Purbach; *l.* Arzachel; *m.* Ptolemaeus; *n.* Hipparchus; *o.* Messier; *p.* Flamsteed; *q.* Triesnecker (clefts); *r.* Schroter; *s.* Stadius; *t.* Copernicus (rays); *u.* Kepler (rays); *v.* Eratosthenes; *w.* Aristarchus (brightest spot on Moon's surface); *x.* Cleomedes; *y.* Archimedes; *z.* Aristillus; *aa.* Aristoteles; *bb.* Plato (floors seems to vary); *cc.* Anaximander; *dd.* Philolaus; *ee.* Grimaldi (darkest spot on Moon's surface).

OTHER FEATURES: 1. Leibnitz Mts.; 2. Dorfel Mts.; 3. Stag's Horn Mts.; 4. Straight Wall; 5. Rays; 6. Ariadaeus Cleft; 7. Hyginus Cleft; 8. Altai Mts.; 9. Riphaen Mts.; 10. Haemus Mts.; 11. Apennines; 12. Carpathians; 13. Caucasus; 14. Cape Heraclides; 15. Alps (with Rift Valley); 16. Mts. of Eternal Light.

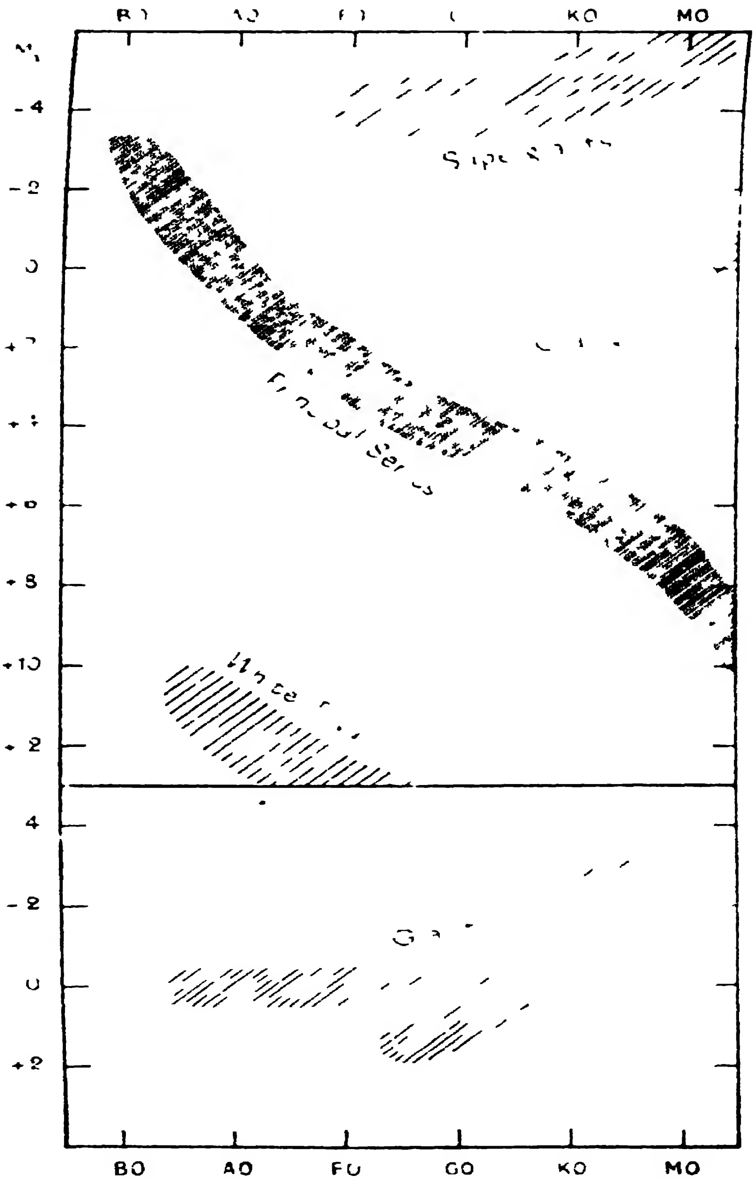
LUNAR SEAS: LS. *Lacus Somniorum*, Lake of the Sleepers; MC. *Mare Crisium*, Sea of Crises; MF. *Mare Foecunditatis*, Sea of Fertility; MFr. *Mare Frigoris*, Sea of Cold; MI. *Mare Imbrium*, Sea of Showers; MN. *Mare Nectaris*, Sea of Nectar; MNu *Mare Nubium*, Sea of Clouds; MS. *Mare Serenitatis*, Sea of Serenity; MT. *Mare Tranquilitatis*, Sea of Tranquillity; MV. *Mare Vaporum*, Sea of Vapours; SA. *Sinus Aestuum*, Bay of Billows; SI. *Sinus Iridium*, Rainbow Bay; SM. *Sinus Medii*, Central Bay; SR. *Sinus Roris*, Bay of Dew.

PLATE IV

THE ORBITS OF THE PLANETS

Planet	Mean Distance from Sun (a)	(in Millions of Miles)	Period P	Eccentricity e	Inclination i	Long. of Node Ω	Long. of Perihelion
Mercury	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Venus	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Earth	1.000	[illegible]	[illegible]	[illegible]			[illegible]
Mars	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Jupiter	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Saturn	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Uranus	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Neptune	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Pluto	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

PLATE [illegible]



Russell Diagram. Absolute visual magnitude m against spectral type. A. Population I.
B. Population II (following Baade) (giant branch)

PLATE VI

Satellites of the Solar System

Name	Stellar Mag	Mean Dist from Planet ″[a]	Mean Dist from Planet Miles	Revolution Period d	h	m	Diameter Miles	Discoverer
ATELLITE OF THE EARTH								
Moon[b]	−12 6	530	238,857	27	07	43	2160	
ATELLITES OF MARS								
hobos	12	8	5,800	0	07	39	10′	Hall, 1877
eimos	13	21	14,600	1	06	18	5′	Hall 1877
ATELLITES OF JUPITER								
	13	48	112 600	0	11	57	100′	Barnard 1892
ı	5	112	261 800	1	18	28	2300	Galileo 1610
uropa	6	178	416 600	3	13	14	2000	Galileo 1610
anymede	5	284	664 200	7	03	43	3200	Galileo 1610
allisto	6	499	1 169 000	16	16	32	3200	Galileo 1610
I[b] [d]	14	3037	7 114 000	250	16		100′	Perrine 1904
II[b] [d]	16	3113	7 292 000	260	01		40′	Perrine 1905
[d]	1[illegible]	3116	7 300 000	260			15′	Nicholson 1938
I[b] [c] [d]	18	5990	13 000 000	692			15′	Nicholson 1938
III[b] [d]	16	6240	14 600 000	739			40	Melotte 1908
[d]	17	6360	14 900 000	758			20′	Nicholson 1914
II[b] [c]	19		15 200,000	[illegible]50			10	Nicholson 1952
ATELLITES OF SATURN								
imas	12	27	115 000	0	22	37	400′	W Herschel 1789
nceladus	12	34	148 000	1	08	53	500′	W Herschel 1789
thys	11	43	183 000	1	21	18	800′	G Cassini 1684
ione	11	55	234 000	2	17	41	700′	G Cassini 1684
hea	10	76	327,000	4	[illegible]	25	1100	Cassini 1672
tan	8	177	759,000	15	22	41	2600	uygens 1655
yperion	13	214	920 000	21	06	38	300′	G Bond 1848
etus[b]	11	515	2,210 000	79	07	56	1000	G Cassini 1671
oebe[b] [c] [d]	14	1870	8 034,000	550			200′	W Pickering 1898
ATELLITES OF URANUS								
iranda[e]	19		85 000	1	10			Kuiper 1948
iel	16	14	119 000	2	12	29	600′	Lassell 1851
mbriel [e]	16	19	166 000	4	03	28	400′	Lassell 1851
ania[e]	14	32	272 000	8	16	56		W Herschel 1787
eron[e]	14	42	364 000	13	11	07	900′	W Herschel 1787
ATELLITE OF NEPTUNE								
ton[b] [c]	13	16	220,000	5	21	03	3000′	Lassell 1846
reid[d]	19		3,460,000	360			200?	Kuiper, 1949

[a] Apparent distance in seconds as seen from the Sun
[b] Orbit highly inclined to plane of planet's equator.
[c] Revolution retrograde
[d] Orbit considerably eccentric
[e] Orbit inclined 82° to plane of planet's orbit

PLATE VII

The Solar System

Object	Symbol	Mean Diameter Miles	Mass ⊕ = 1	Density Water = 1	Axial Rotation	Mean Surface Gravity ⊕ = 1	Albedo	Magnitude When Brightest
Sun	⊙	864,000	332,000	1 4	24^{17} equatorial	27 9		26 7
Moon	☾	2,160	0123	3 3	27^{d} 7 7^{h}	16	07	12 6
Mercury	☿	3 010	056	3 8	88^{d}	37	07	0
Venus	♀	7 580	82	4 9	30^{d}	85	59	4
Earth	⊕	7 918	1 00	5 5	$23^{h}\ 56^{m}$	1 00	29	
Mars	♂	4 220	108	4 0	$24^{h}\ 37^{m}$	38	15	− 2 ±
Jupiter	♃	87,000	318	1 3	$9^{h}\ 50^{m}$	2 6	56	2
Saturn	♄	72,000	95	7	$10^{h}\ 15^{m}$	1 2	63	0
Uranus	♅	31,000	14 6	1 3	$10^{h}8$	9	63	+ 5
Neptune	♆	33,000	17 2	1 3	16^{h}	1 0	73	+ 7
Pluto	♇	4,000	< 1					+ 14

PLATE VIII

THE PRINCIPAL STELLAR SPECTRAL TYPES

Distinguishing Feature	Example	Number of Stars Brighter than Mag 6.25	Color Index	Effective Temperature
Ionized helium	ζ Puppis	20	− 0.3	>30,000°
Neutral helium	ε Orionis	696	− 0.3	20,000
Strong hydrogen lines	Sirius	1885	0.0	11,000
Intermediate class	Procyon	720	+ 0.3	7,500
Many metallic lines, strong H and K	The Sun	609	+ 0.6	6,000
Intermediate class	Arcturus	1719	+ 1.0	4,200
Titanium oxide bands	Antares	457	+ 1.5	3,000
Carbon bands	19 Piscium	8	+ 2.5	3,000

PLATE IX

THE BRIGHTEST STARS

Stars Brighter than Visual Magnitude 1 50

	Mag	Sp	Dist in l.-y.		Mag	Sp	Dist in l. y
α Canis Maj. (Sirius)	− 1 58	A0	8 6	α Orionis (Betelgeuse)	1 0		
α Argûs (Canopus)	− 0 86	F0	100		to 1 4	M2	300
α Centauri	+ 0 06	G0	4 3	α Crucis	1 05	B1	220
α Lyrae (Vega)	0 14	A0	27	α Tauri (Aldebaran)	1 06	K5	53
α Aurigae (Capella)	0 21	G0	42	α Virginis (Spica)	1 21	B2	120
α Bootis (Arcturus)	0 24	K0	33	β Geminorum (Pollux)	1 21	K0	29
β Orionis (Rigel)	0 34	B8	540	α Scorpii (Antares)	1 22	Ma	250
α Canis Min (Procyon)	0 48	F5	11	α Piscis Australis			
α Eridani (Achernar)	0 60	B5	70	(Fomalhaut)	1 29	A3	23
β Centauri	0 86	B1	190	α Cygni (Deneb)	1 33	A2	400
α Aquilae (Altair)	0 89	A5	15 7	α Leonis (Regulus)	1 34	B8	67

Stars of Visual Magnitude 1 50 to 2 00

	Mag	Sp	Dist in l. y		Mag	Sp	Dist in l. y
β Crucis	1 50	B1	272	β Argûs	1 80	A0	?
α Geminorum (Castor)	1 58	A0	47	α Trianguli Australis	1 88	K2	130
γ Crucis	1 60	Mb	72	α Persei	1 90	F5	130
ε Canis Majoris	1 63	B1	326	η Ursae Majoris	1 91	B3	130
ε Ursae Majoris	1 68	A0	48	ζ Orionis	1 91	B0	410
γ Orionis (Bellatrix)	1 70	B2	250	γ Geminorum	1 93	A0	93
λ Scorpii	1 71	B2	204	α Ursae Majoris	1 95	K0	109
ε Argûs	1 74	K0	326	ε Sagittarii	1 95	A0	163
ε Orionis	1 75	B0	410	δ Canis Majoris	1 98	F8	410
β Tauri	1.78	B8	93	β Canis Majoris	1 99	B1	360

PLATE X

Astronomical Symbols

Symbols of the Sun, Moon, and Planets

☉	The Sun	♃	Jupiter
☾	The Moon	♄	Saturn
☿	Mercury	♅	Uranus
♀	Venus	♆	Neptune.
⊕	The Earth	♇	Pluto.
♂	Mars		

Signs of the Zodiac

1	♈	Aries	7	♎	Libra
2	♉	Taurus	8	♏	Scorpius
3	♊	Gemini	9	♐	Sagittarius
4	♋	Cancer	10	♑	Capricornus.
5	♌	Leo	11	♒	Aquarius.
6	♍	Virgo	12	♓	Pisces

Other Symbols

☌ Conjunction, or having the same longitude or right ascension.
☍ Opposition, or differing 180° in longitude or right ascension.
□ Quadrature, or having a geocentric angular distance of 90°.
☊ Ascending node
☋ Descending node.

°	Degrees	h	Hours.
′	Minutes of arc	m	Minutes of time.
″	Seconds of arc.	s	Seconds of time.

PLATE XI

The Zodiacal Constellations

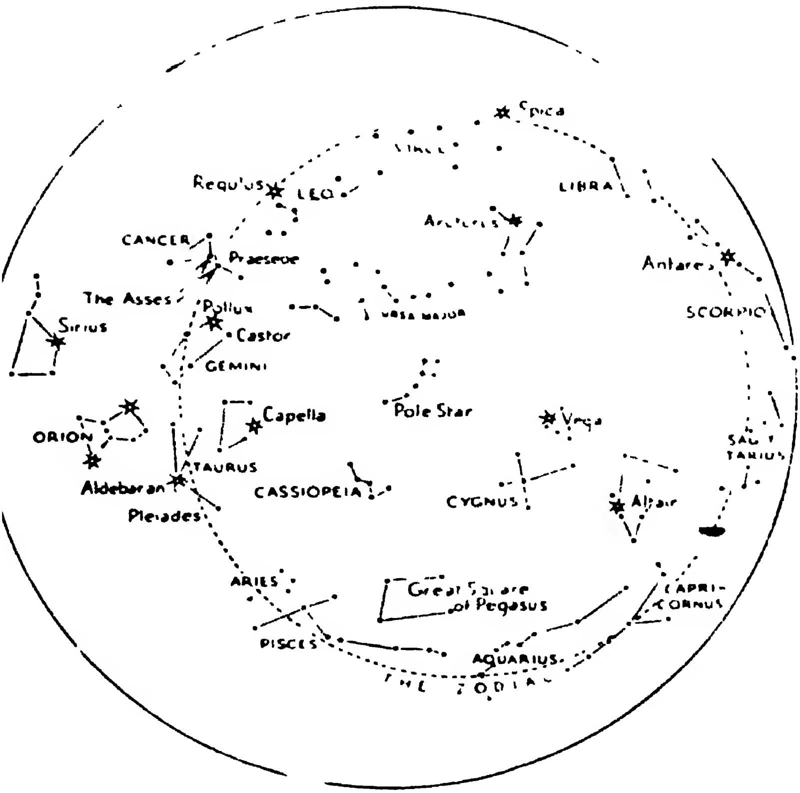


PLATE XII

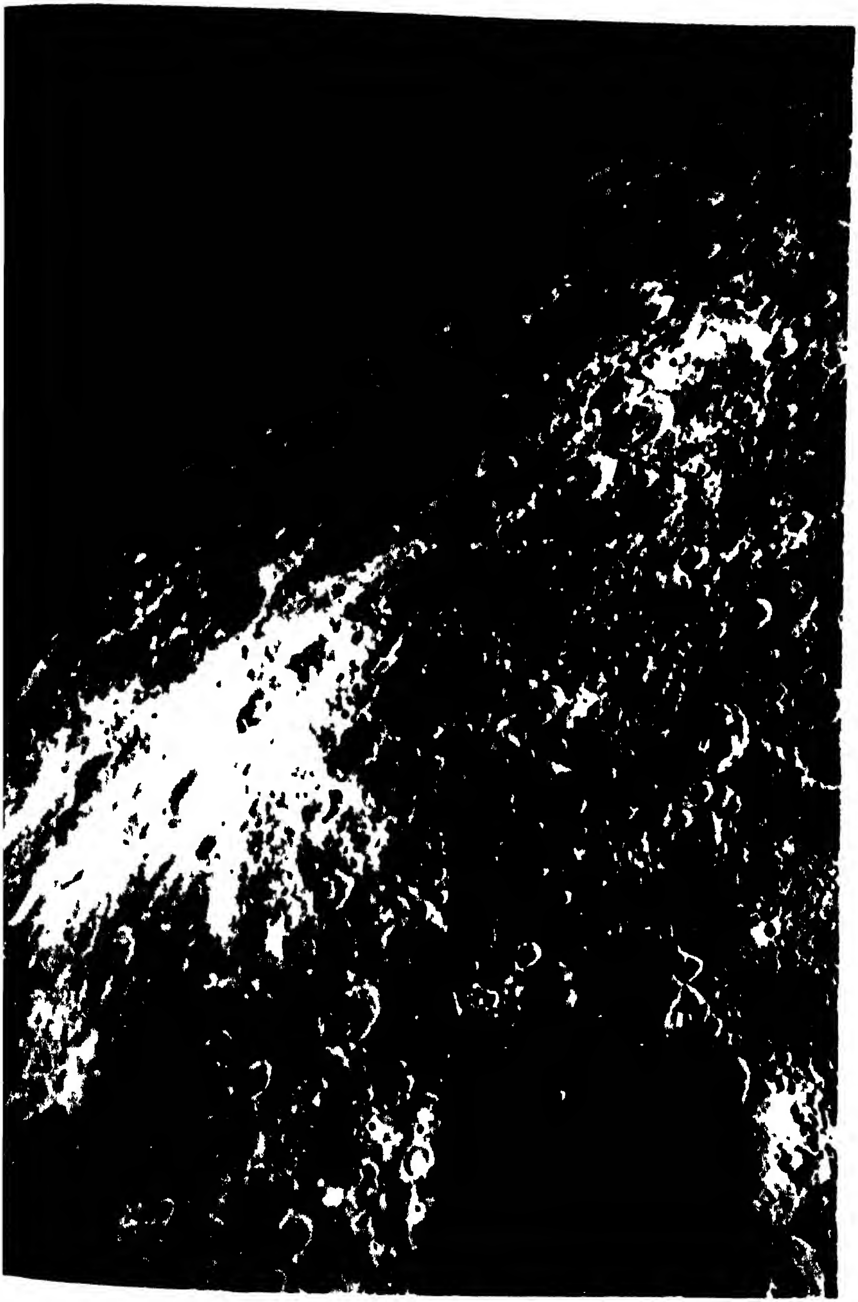
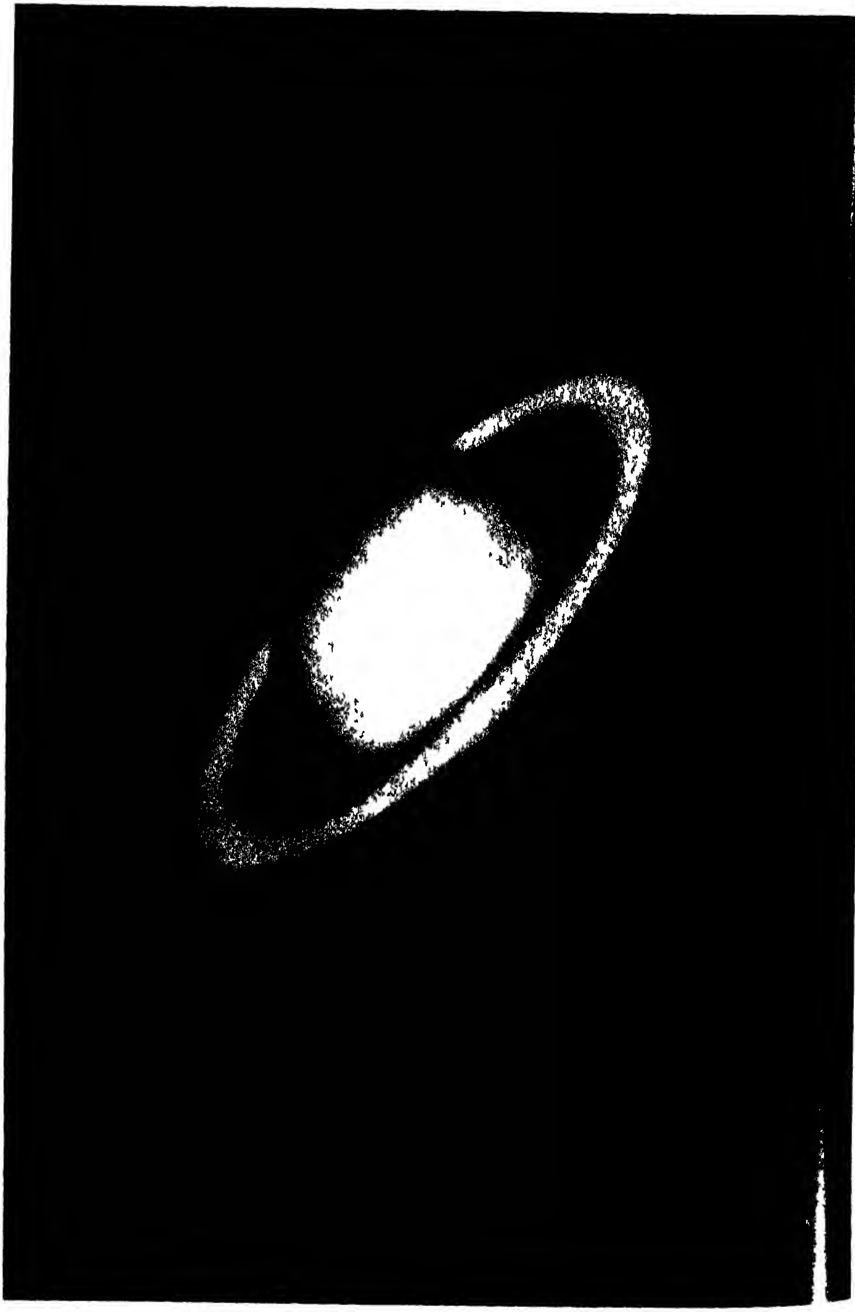


PLATE XIII The Moon



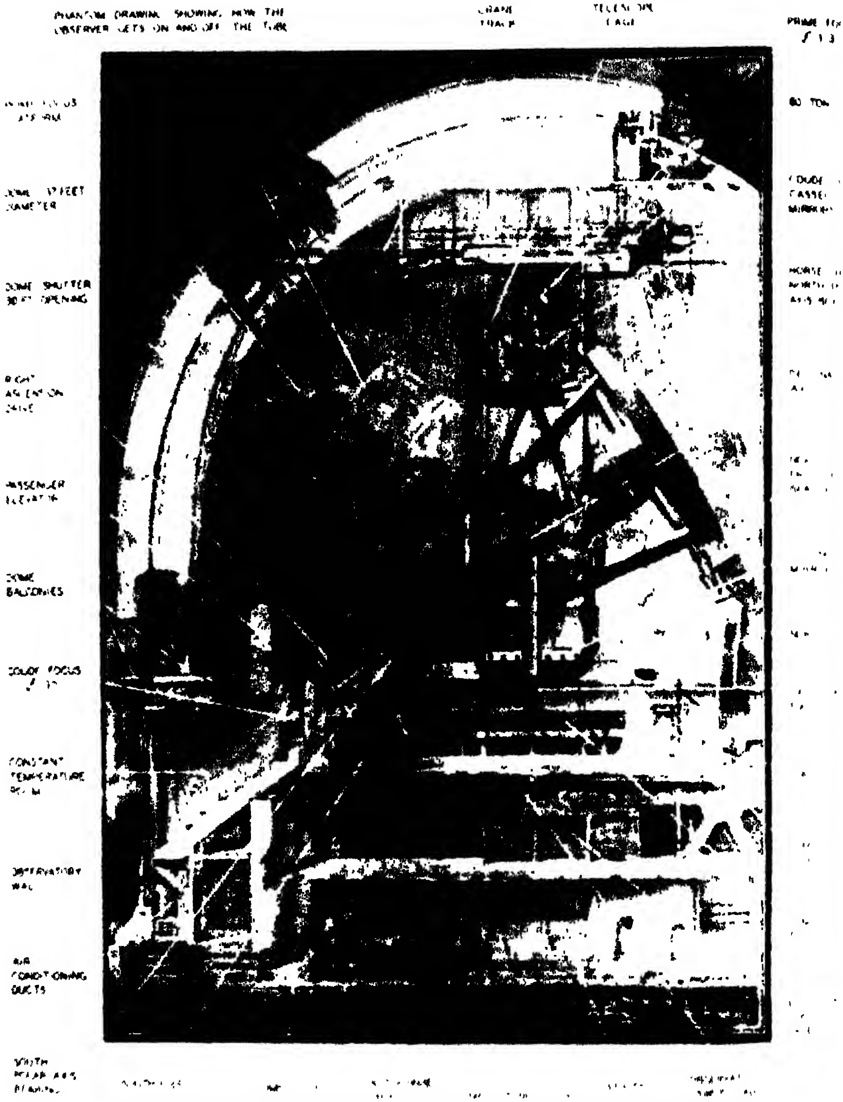


PLATE XVI 200-inch Hale Telescope and Dome

Lambert conformal projection

Representation of small parts of the earth's surface by projecting it to a cone which cuts the earth at two standard parallels, the area between which is used for the chart. Meridians are straight lines converging toward the nearest pole, and parallels of latitude are concentric circles. Angles are correctly represented.

landing rocket

(ASTRONAUTICS) A "secondary rocket" intended to be used for descending to the surface of the moon or another planet while the major vehicle remains in an orbit around the destination body.

Lane's law

The temperature of a perfect gas is inversely proportional to its radius.

This is sometimes stated in the form of a paradox. If a star cools, and therefore contracts, it becomes hotter.

last quarter

The phase, also called *third quarter*, of the moon at its western quadrature, when it is visible as a semicircle. (*see* PHASES.)

latent heat

The amount of heat necessary to change a given amount of a solid into a liquid, or of a liquid into a gas, without increasing its temperature.

The latent heat of melting ice is 80 calories per gram.

The latent heat of evaporation of water is 540 calories per gram.

latent period

In radiobiology and health physics, the interval between an exposure to radiation and the appearance of its effect.

latent tissue injury

In radiobiology and health physics, an injury owing to exposure to radiation which does not manifest itself for some time (and perhaps not until another injury, insignificant in itself, has occurred).

latitude

Angular distance north or south of the equator, measured in degrees from 0 to 90, along the meridian. (*see* ASTRONOMICAL LATITUDE, DIFFERENCE OF LATITUDE, GALACTIC LATITUDE, GEOGRAPHIC LATITUDE, HELIOCENTRIC LATITUDE, HELIOGRAPHIC LATITUDE, MIDDLE LATITUDE).

launching pad

The concrete platform upon which a rocket sits prior to launching. Usually the rocket sits on the *firing table*, and there is a *blast deflector* beneath to channel the exhaust away from the rocket.

launching tower

A steel structure erected for servicing, aiming and launching of certain rockets.

law of the conservation of angular momentum

The total angular momentum of a system is always the same, if no external force acts on the system.

law of conservation of energy

The total amount of energy in an isolated system remains unchanged while internal changes take place.

law of conservation of mass

The total mass of any material system is neither increased nor diminished by reactions between individual parts.

law of conservation of moment of momentum

In an isolated system of revolving bodies, the sum of all the moments of momentum remains unchanged.

law of conservation of momentum

The total momentum of a dynamical system consisting of any given number of material particles remains constant if the only forces acting are the mutual interaction forces of these particles.

law of equal areas

When a body is moving undisturbed by any force whatever, its radius vector, from any center, describes equal areas in equal times around that center.

The area of the triangle described by the radius vector in a unit of time is called the *areal velocity* of the body, and it is constant.

As the earth revolves around the sun the line joining their centers sweeps over equal areas in equal intervals of time. Because the distance varies, the seasons are of unequal length.

laws of motion

Newton's three laws of motion form the basis of all mechanics:

1. Every body persists in its state of rest or of uniform motion in a straight line unless it is compelled to change that state by a force impressed on it.

2. The acceleration is directly proportional to the force, and inversely to the mass of the body, and it takes place in the direction of the straight line in which the force acts.

3. To every action there is always an equal and contrary reaction; or, the mutual actions of any two bodies are equal and in opposite directions. (*see* also KEPLER'S LAWS.)

laws of radiation

(*see* RED SHIFT, EXPANDING UNIVERSE.)

law of the red shifts

E. Hubble's term for the relationship between the speed of the *recession* and the distance of nebulae, viz., the observation that the speed of recession increases roughly 100 miles a second for each million of light years of increase in the distance.

lead

The metal lead is one of the disintegration products of the radioactive metals uranium and thorium. It occurs in the earth as three isotopes.

Ordinary lead has an atomic weight of 207. That derived from uranium has 206, and that from thorium has 208.

By determining the amounts of lead-206 and 208 in any rock and knowing the rate of disintegration of uranium and thorium, it is possible to approximate the age of the rock.

This method is used in estimating the age of the earth, and the lengths of the geologic periods.

leap year

A year with 366 instead of 365 days. They are necessary so that the calendar will agree with the seasons. The rule for leap years is that any year evenly divisible by four is a leap year (such as 1956, 1960, etc.). The exception to the rule is that centennial years (such as 1800, 1900, etc.) must be divisible by 400 in order to be leap years. Thus 2000 will be the first centennial leap year since 1600. The year now disagrees with the seasons by one day in about 3,000 years—something that can be taken care of by dropping a leap year at the appropriate time.

Lemaitre's theory

see EXPANDING UNIVERSE.

lens

A piece of glass, or of quartz or transparent plastic, having one or two curved surfaces, used in many optical instruments.

Light is always refracted (bent) toward the thickest part of the lens. There is always some dispersion, separation of light into its colors.

There are two kinds of lenses:

CONVEX. Thickest in the center, thin at the edge. These are converging lenses, and refract the light to a focus. They are magnifying lenses.

CONCAVE. Thick at the edge, thinnest in the center. These are diverging lenses and make objects look smaller.

Both classes may have one plane side, or both sides curved. The curved surfaces may be parts of a sphere or of a cylinder. (*see* EYE LENS, FIELD LENS, OBJECTIVE.)

Leo the Lion

The fifth constellation in the zodiac.

A large constellation in the evening sky in spring.

It represents the Nemean Lion, slain by Hercules as the first of his twelve labors.

Seven of the principal stars form a sickle whose blade marks the head of the animal, with the brightest star at his heart. Farther east is a right triangle with Denebola at its eastern point making the brush on the lion's tail.

Regulus, at the heart, is red and next to the faintest of the 20 first magnitude stars.

The Leonid meteor shower, visible Nov. 14 to 18, radiates from a point within the blade of the sickle.

Leo [the Little Lion]

A northern constellation (between Leo and Ursa Major).

Leonids

A meteor shower, the RADIANT (q.v.) of which lies in the constellation Leo, near ϵ Leonis, and moves from night to night. It is visible between November 10 and 15, consists of very rapidly moving meteors. Associated with Temple's comet of 1866.

Lepus [the Hare]

A small constellation just under the feet of Orion. It contains three 3rd, six 4th magnitude stars, and a few fainter ones.

It probably represents the animal that Orion was hunting, and that is trying to hide beneath his feet. There are few stories connected with it.

Alpha Leporis is a double star, pale yellow and gray.

Beta is a triple of 3rd, 10th and 11th magnitudes.

Near to Alpha is a sextuple that can be seen with a small telescope.

Near by is the famous "crimson star," one of the reddest stars in the sky.

Lexell's Comet

In 1770 this small comet passed within about two million miles of the earth. Its orbit was greatly changed by the earth's attraction, but its attraction made no appreciable difference in the orbit of the earth, proving that the mass of the comet was very small.

In 1779 this comet passed close to Jupiter. Its orbit was very greatly enlarged, and the comet has never been seen since.

Libra [the Scales]

The seventh constellation in the zodiac, between Virgo and Scorpius.

It probably represents the balancing of day and night, for the autumn equinox was in this sign when the constellation was described in ancient Mesopotamia.

For the Greeks these stars were the claws of the scorpion, which in their early zodiac covered the space of two signs. It was separated by the Romans about the time of Julius Caesar, and given its Egyptian name. The names of the two brightest stars still mean the northern and southern claws.

Alpha, the southern claw, is a wide double.

Beta, the northern claw, is the only green star of naked eye brightness, and is variable.

Delta is an eclipsing binary, with a period of 2 days 8 hours.

libration

A real or apparent oscillatory motion of a body, like that of a balance before it comes to rest.

librations of the moon

The moon rotates in the same time that it revolves about the earth, and so keeps one face toward us all the time.

But the moon seems to rock slightly. It has three librations.

Libration in latitude. The axis of the moon is tilted 6½° to the plane of its orbit. That lets us see 6½° beyond the north pole at one time in the month, and beyond the south pole at another time. This is similar to the change of seasons on the earth.

Libration in longitude. Because the moon's orbit is an ellipse, it moves faster at some times than at others. This lets us see 7¾° farther around in longitude at each edge than we could if its orbit were a circle.

Daily libration is produced by the earth's rotation. Because we are elevated 4000 miles above the center of the earth we can see one degree farther over the western edge at moonrise, and the same amount over the eastern edge at moonset.

These librations mean that during the month we can see 59% of the surface of the moon. 41% of it is forever hidden from our view.

life on other planets

Life, as we know it, requires air, water and temperatures within rather narrow limits.

The moon, other satellites and Mercury have no atmospheres and no water. The giant planets and Pluto are so far from the sun that their temperatures are too low. and their atmospheres are made up of poisonous gases.

Venus is cloud-covered so that we can see nothing, but the apparent absence of water and oxygen and the presence of a large amount of carbon dioxide, seem to make life very questionable if not impossible.

Mars has a thin atmosphere, apparently a little water and is not impossibly cold. We think the green areas are covered with plants, of some kind. We have no evidence of animals nor of anything approaching human life.

light

That which makes things visible. For the various theories

of its nature see: CORPUSCULAR THEORY, ELECTROMAGNETIC THEORY, QUANTUM THEORY, WAVE THEORY.

light curve

A graph showing the course of the variations in brightness of a VARIABLE STAR (q.v.). It is usually plotted with stellar magnitude as the vertical co-ordinate (ordinate) and time, in hours or days as the horizontal co-ordinate (abscissa). The shape of the curve gives the ratios of the diameters of the components to the diameters of their relative orbits around each other.

light-gathering power

The brightness of the image of a star increases in proportion to the area of the objective lens, or to the square of its diameter.

A star appears 100 times as bright with the 100-inch as with a ten-inch telescope, or 250,000 times as bright as with the naked eye.

The purpose of large lenses or mirrors is to gather more light from faint objects.

The 200-inch telescope will gather 4 times as much light as the 100-inch one.

light-grasp

The LIGHT-GATHERING POWER of a telescope (q.v.).

light pressure

see PRESSURE OF LIGHT.

light-ratio

The number that expresses the ratio of the light of a star to that of another one magnitude fainter.

The ratio that has been adopted is the fifth root of 100 ($\sqrt[5]{100}$) which is about 2½.

light-year

A measure of distance, equal to the distance traveled by

light in one mean solar year, i.e., 9,461,000,000,000 km = 5,880,000,000,000 miles.

limb

The edge of the disk of the sun, moon or a planet.

limb darkening

The sun is brightest in the center and darkens toward the limb.

This is due to the atmosphere of the sun which becomes hazy in its lower regions. We see farthest into the sun near the center of the disk and less far near the limb. Thus the regions near the edge correspond to higher, cooler levels, which radiate less light and heat than does the center.

limb effect

It has been observed that the lines in the solar spectrum are slightly shifted toward the red in light from the limb of the sun as compared with light from the center.

This has not been very satisfactorily explained, but is probably due to a combination of the Doppler effect with that of rising currents of gas in the reversing layer.

Limiting Magnitudes

The faintest object that can be detected with the eye, telescope, photographic plate, or photoelectric photometer, is said to mark the limiting magnitude of the system concerned.

line of apsides

The diameter of an elliptic orbit: the line that passes through both foci and connects the point of the greatest distance and the point of the least distance between the body describing the orbit and its primary. (Also called *apse line.*)

line of position

Straight or curved line on some point of which the observer is located. An intersection of two or more lines of position gives a FIX (q.v.).

line of sight

The straight line joining the eye of the observer to the object being observed.

line profile

A curve that shows the internal variation in intensity of a spectral line.

linear diameter

see DIAMETER.

lines of force

The lines that indicate the direction in which a magnetized needle will point at different places in the magnetic field. The points toward which the lines of force converge are called the MAGNETIC POLES.

lines of the spectrum

see SPECTRAL LINES.

liquid-propellant rocket

A ROCKET (q.v.) the motor of which burns a liquid propellant.

lithosiderites

A type of the stony-iron meteorites known as SIDEROLITES (q.v.).

local cluster of stars

The group of stars of which our sun is a member. This group, also called the *local star cloud*, is considered to be lens-shaped, about 2000 light-years in diameter and about 650-700 light-years in thickness, and to be in turn a member of the MILKY WAY GALAXY.

local group of galaxies

A group of at least 17 known galaxies which together fill an ellipsoidal volume of space the longest dimension of which

is 2,000,000 light years. The Andromeda spiral is the largest of the group, and our Milky Way Galaxy the second largest; the two are situated near the opposite ends of the 2-million-light-year distance.

local hour angle

The arc of the equator, or the angle at the celestial pole between the upper branch of the celestial meridian of a place and the hour circle of a body, measured westward from the celestial meridian through 360°. (Sometimes through 24 hours.) A local hour angle measured from the celestial meridian of Greenwich is called a Greenwich hour angle.

local sidereal time

Local hour angle of the vernal equinox, expressed in hours, minutes and seconds.

local star cloud

see LOCAL CLUSTER OF STARS.

local time

Time as measured by the sun for any separate locality on the earth.

It varies as we go east or west, at the rate of 8 minutes for a hundred miles in latitude 40°.

It was the kind of time used before the building of railroads and the adoption of standard time. (*see* TIME.)

long-period variables

VARIABLE STARS (q.v.), the periods of which range from about 100 to more than 600 days, with a strong concentration in the range of 200 to 400 days. They are giant stars of low temperature spectrum. The Harvard Catalogue lists 1760 of them, of which about 1100 are *M* type, and the majority of the rest S, *R* or *N* types, all with bright lines in the spectra. The variation of visual brightness is about 20 to 1500 times (3 to 8 magnitudes) between maximum and minimum light,

averaging about 100 times (5 magnitudes). The periods and amplitudes of variation are known to increase on the average with redness.

longitude

The angular distance east or west of the prime meridian measured to the meridian passing through a point, from 0° to 180°. (Cf. DIFFERENCE OF LONGITUDE.) Also may be measured in hours minutes and seconds of time difference.

longitude circle

The great circle, on the celestial sphere, drawn through the pole of the ecliptic and the point to be measured.

This is used in the ecliptic system of coordinates in treating problems of eclipses of the sun and the moon.

Loop Nebula

One of the largest and brightest gaseous nebulae known.

It is in the large Magellanic Cloud which is 150 000 light years away, but it is visible to the naked eye.

In many respects it is very like the Orion Nebula, but is more than 4,000 times as large. Its diameter is about 260 light-years. At its center is a cluster of 100 or more supergiant, blue stars, which together give 100 times as much light as the globular cluster in Hercules.

If the Loop Nebula were placed where the Orion Nebula is, it would fill the whole constellation of Orion, and would give light enough to cast shadows on the earth.

There is nothing like it in our galaxy. It is also known as the Tarantula and as 30 Doradus.

Lorentz-Fitzgerald contraction theory

A hypothesis formulated by Fitzgerald in 1893 and extended to electromagnetic phenomena by Lorentz in 1895, stating that a body moving through space undergoes a shrinkage in the direction of its motion.

low high tides

The high tides which occur near the moon's first or third quarter. (*see* NEAP TIDES, TIDES.)

low low tides

The low tides which occur near new or full moon. (*see* SPRING TIDES, TIDES.)

low tide

The lowest level reached by a descending tide.

low water

see LOW TIDE.

lower branch of the celestial meridian

That portion of the celestial meridian which extends from pole to pole through the nadir.

lower high water

The lower of the two high tides occurring at a place during a lunar day.

lower low water

The lower of the two low tides occurring at a place during a lunar day. (*see* TIDES.)

lower transit

Passage of a celestial body across the lower branch of the celestial meridian.

lox

(ASTRONAUTICS) A colloquial term for liquid oxygen.

loxodrome, loxodromic curve

Every RHUMB LINE (q.v.) except for the equator and the parallels of latitude.

lucid star

A naked-eye star.

lucida

The name often given to the brightest star in a constellation.

lumen

A unit of intensity of light.

A source of one candlepower emits 4π lumens of light per second, or 12.57 lumens.

luminosity

Brightness. The luminosity of a star is the ratio of the amount of light that would reach us from it to the amount that would reach us from the sun if both the star and the sun were removed to the same standard distance from us. (*see* ABSOLUTE LUMINOSITY, DISTANCE-LUMINOSITY RELATION, MASS-LUMINOSITY RELATION, OVERLUMINOUS, PERIOD-LUMINOSITY RELATION, UNDERLUMINOUS.)

Luna

The moon.

lunar aspects

The different appearance of the moon due to its angular distance from the sun.

The same as phases, but includes all the changes and not only the four principal ones.

lunar day

see DAY.

lunar distance

The angular distance of the center of the moon from the sun or the planets and the bright stars in its path; used in nautical astronomy.

lunar eclipse

see ECLIPSE OF THE MOON.

lunar month

see SYNODIC MONTH.

lunar nutation

The NUTATION (q.v.) due to the motion of the moon's nodes. It amounts to 9.2 seconds in a period of 19 years.

lunar parallax

The parallax of the moon: the angle subtended at the moon by the equatorial radius of the earth.

lunar seas

see MARIA ON THE MOON.

lunar space

Space near the moon, where the gravitational attraction of the moon is predominant.

lunar star

A star used in nautical astronomy for the determination of terrestrial longitudes by comparing its LUNAR DISTANCE (q.v.) with the distance calculated for a certain hour and longitude.

lunation

The period of time between two successive new moons. The same as a lunar month or synodical month. It averages 29 days 12 hours 44 minutes 28 seconds.

lunitidal interval

Average interval between the meridian transit of the moon at any point and the next high tide. (*see* TIDES.)

Lupus [the Wolf]

A southern constellation.

Lynx [the Lynx]

A northern constellation.

Lyra [the Lyre]

A small constellation that contains Vega, the brightest star in the summer sky.

It represents the lyre of Orpheus, which was put into the sky by the gods after the death of the famous musician.

In Lyra are the double-star Epsilon Lyrae, two double stars revolving about each other. Beta Lyrae an eclipsing binary with a period of 12 days 22 hrs., and the Ring Nebula, brightest of planetary nebulae.

Lyrids

A meteor shower, the RADIANT (q.v.) of which is in the constellation Lyra, consisting of swift meteors, of which 8-10 can be observed per hour at the maximum (April 20-21).

M

M regions

The areas of the sun's surface presumably responsible for magnetic disturbances on the earth.

Mach number

The ratio between the velocity of a moving object and the velocity of sound in the same portion of the atmosphere. Mach 1 (abbreviated M-1) is therefore, by definition, the speed of sound, thus, e.g., M-5 denotes a speed 5 times that of sound.

Mach wave

A shock wave set up by an object traveling with a Mach number above unity.

macula

A dark spot on the sun or on some other luminous body.

Magellanic Clouds (Clouds of Magellan)

Two irregular clouds of stars, easily visible to the naked eye, near the south celestial pole. They are the nearest of the external galaxies, and are often called the two "satellites" of our galactic system.

The Large Cloud is in the constellation Doradus, the Swordfish. It is 150,000 light-years away, and nearly 30,000 light-years in diameter. It contains the super-giant variable star, S Doradus, which is one of the most brilliant stars known in the whole universe, being 2,000,000 times as bright as the sun; and

the great Loop Nebula, a gaseous nebula many times larger and brighter than the great nebula in Orion.

The Small Cloud is farther away, about 170,000 light-years in the constellation Tucana.

Both clouds contain giant and variable stars, clusters and nebulae.

magnetic compass

A compass that depends entirely on the earth's MAGNETIC FIELD for its directive force, without the aid of any elaborate mechanism. Its indicator needle always points in the direction of the earth's magnetic lines of force, and therefore to the MAGNETIC POLES (q v.).

magnetic crochet

An abrupt change in the magnetic field of the earth, produced on the daylight side by currents generated in the upper layers of the atmosphere.

magnetic equator

A GREAT CIRCLE (q.v.) on the earth, every point of which is 90° from the magnetic poles, its plane is at right angles to the magnetic axis of the earth.

magnetic field

The region around a magnet in which its influence is felt. The LINES OF FORCE show the direction in which a magnetized needle will point at different places in the field, they converge toward the MAGNETIC POLES (q.v.).

magnetic field of the sun

The rotation of the sun makes the entire sun a magnet, in the same way that the earth is a magnet.

The field is quite weak and can not be measured more than 200 miles above the photosphere.

Field of sunspots. The whirling of the gases that causes a sunspot, makes every spot the center of a magnetic field. The polarity of the spots varies as to whether they are in the northern or southern hemisphere of the sun.

magnetic meridian

At any place on earth, the line in which the terrestrial magnetism exerts its force.

magnetic pole

In a magnetic field, one of those points toward which the lines of force converge. (*see* MAGNETIC POLES OF THE EARTH.)

magnetic poles of the earth

The places where the magnetic field of the earth is perpendicular to the surface. These are the points where the magnetic lines of force of the earth converge.

magnetic storm

A sudden violent disturbance of the earth's magnetic field, shown by erratic variations of the compass needle, and sometimes by serious interference with radio, telegraph and telephone communication.

Such storms occur about a day after a large sun-spot has crossed near the center of the sun. They are believed to be caused by streams of electrified particles shot out from the vortex of the sunspot.

magnetism

The unascertained cause of the magnetic force or power of attraction; also, the property or state of possessing or having acquired this power or a magnetic field.

magnetograph

An apparatus, based on the ZEEMAN EFFECT (q.v.) designed and employed for studying and mapping the magnetic field of the sun.

magnifying power of a telescope

The focal length of the objective lens divided by the focal length of the eyepiece (e.g., if the focal length of the objective is 180 inches, and that of the eyepiece is ½ inch, the object is magnified 360 times.) The magnifying power of a telescope is thus dependent on its focal length.

Telescopes usually have a number of eyepieces of different focal lengths, so that the magnification can be varied. The highest powers can be used only when the seeing conditions are very good.

magnitude

The measure of the relative brightness of a celestial body. The lower the numerical value of the magnitude of a body the brighter it is relative to the others. A body of magnitude 1.0 is 2.512 times as bright as one of magnitude 2.00, which in turn is 2.512 times as bright as one of magnitude 3.00, etc. (Thus the body of magnitude 1.0 is 2.512^2, i.e., 6.310 times as bright as the body of magnitude 3.00) This ratio between successive whole magnitudes, 2.512 to 1, was chosen since it is the fifth root of 100, and is known as the MAGNITUDE RATIO, also called POGSON'S RATIO for the astronomer who introduced it. While magnitudes are usually listed to the nearest one-tenth, it is customary to refer to all bodies of magnitude 1.5 or brighter as of "first magnitude," to those between magnitudes 1.5 and 2.5 as of "second magnitude," etc. The magnitudes of celestial bodies are expressed in various ways, according to the method or process of observation and determination employed.

The magnitudes of stars vary greatly. Naked eye stars are classed as magnitudes 1 to 6. With the best telescopes we can see stars of the 20th magnitude, and photograph those of the 23rd.

The sun is of visual magnitude —26.72. Its absolute magnitude is +4.85. That means if the sun were as far away as Pollux in Gemini, it would appear as a fifth magnitude star.

The visual magnitude of Sirius is —1.43. Its absolute magnitude is +1.3 which means that it is really 27 times as bright as the sun.

Rigel is of absolute magnitude —6.2 about 14,000 times as bright as the sun. Only a very few stars are known that are as bright as Rigel.

One of the faintest stars is known as Barnard's Star, only 1/2500 the brightness of the sun.

There are probably some stars that are entirely dark.

(*see* ABSOLUTE MAGNITUDE, APPARENT MAGNITUDE, BOLOMETRIC MAGNITUDE, MEDIAN MAGNITUDE, PHOTOELECTRIC MAGNITUDE, PHOTOGRAPHIC MAGNITUDE, PHOTOVISUAL MAGNITUDE, RADIOMETRIC MAGNITUDE, VISUAL MAGNITUDE.)

magnitude lines

Certain spectral lines of calcium, hydrogen, iron and strontium, which can be correlated with the absolute magnitudes of the stars in the spectra of which they occur.

magnitude ratio

The ratio between successive stellar magnitudes, i.e., 2.512 to 1. (*see* MAGNITUDE).

main sequence stars

The stars which are in the smooth curve called MAIN SEQUENCE of the RUSSELL DIAGRAM (q.v.); it includes the great majority (about five-sixths) of all the known stars. Our sun is near the middle of the curve.

major axis of an ellipse

The straight line that passes through both foci, the center and the vertices of the ellipse.

major planets

The four planets that are larger than Earth: Jupiter, Saturn, Uranus and Neptune.

map

Representation on a flat surface of a curved surface; as for example, maps of portions of the earth, moon or sky. Distortion is minimized at the expense of irregularities in the coordinate grids. (Cf. CHART, PROJECTION.)

March equinox

The *vernal equinox* (*see* EQUINOX).

maria on the moon

When Galileo looked at the moon with his first, little telescope, the large, dark areas looked to him like great bodies of water, and he named them *maria* meaning *seas*. He gave the various ones fanciful names, Sea of Showers, of Serenity, of Tranquility, etc.

Showers is the largest, over 700 miles in diameter. Serenity is 430 miles. Both are nearly circular.

They are not seas, for there is no water there. They are plains, nearly smooth and flat except for the curvature of the surface, and, of course, desert, without air or moisture.

These dark areas make up the fanciful pictures of the "man in the moon," the "lady with the book," the rabbit, donkey, crab, etc. (*see* MOON.)

Mars

The planet that was named for the god of war, because of its red color, suggesting the color of blood.

The fourth planet out from the sun. Mean distance 141,500,000 miles. Its distance from the earth varies from 34.6 to 234 million miles. Therefore its brightness varies greatly.

Diameter 4,216 miles, a little more than one-half that of the earth.

Period of revolution 687 days, i.e., nearly 2 years.

Period of rotation 24 hrs. 37 min. 22.6 seconds.

Mass only .11 that of the earth.

Density 3.96 that of water.

Surface gravity .38 that of the earth. A 150-pound man would weigh 57 pounds on Mars.

Mars has two very small satellites called DEIMOS and PHOBOS (qq.v.).

Mars has an atmosphere very much less extensive than that of the earth. It is estimated to be about 60 miles deep. At the surface it would be less dense than the air on the top of the highest mountain on earth.

Because of the thin air and the practical absence of clouds, we can see the surface better than that of any other planet.

The red color is thought to be due to absorption of oxygen by the surface rocks giving them the color of iron rust. We can find no oxygen in the atmosphere now.

Because it is farther from the sun than the earth, the temperature is lower. Highest ever recorded is 86°F at the equator in summer. It probably freezes every night.

White caps about the poles are believed to be ice or snow. Their size changes with the seasons, sometimes disappearing in summer and becoming very large in winter.

Mars' axis is inclined to its orbit at 24°50′ which is very similar to that of the earth (23°30′). Therefore it has four seasons as the earth has. Because of the longer year, each season is nearly six of our months long.

The surface is mostly red, thought to be the base surface of a desert. There are probably no high mountains, but perhaps some differences of level. Some large areas appear green in summer and brown or red in winter. Perhaps there are places where plants grow when the melting snow of the polar caps furnishes a little water.

Sometimes very faint, dark lines are seen which have been called canals. Few people believe that they are artificial. What they are we do not know. There is no evidence for any life other than the possible plants in the green areas. (*sc* CANALS OF MARS.)

maple leaf

A four-finned device designed to slow the fall of packages containing scientific instruments dropped from research rockets or balloons.

maser

The designation coined from the initials of the phrase "Microwave Amplification by Stimulated Emission of Radiation," denoting a device introduced in 1957 which, among

several other applications in physics, chemistry, radio and television communication, is expected to increase the utility of radio telescopes a hundredfold.

mass

The quantity of matter that a body contains.

The arbitrary unit of mass is the quantity of matter in a block of platinum preserved at Paris, and called one kilogram. There is also a standard pound, in Washington, another in London.

Mass is not quite the same as WEIGHT (q.v.) but for practical purposes the masses of two bodies are compared by weighing them at the same place. In space, however, a body loses a part or all of its weight, but its mass remains constant.

mass-energy relation

The statement of the equivalence and interconvertibility of a quantity of energy and quantity of mass, i.e.: $E = mc^2$, where E is the quantity of energy in ergs, m is the quantity of mass in grams, and c is the velocity of light in centimeters per second. This is the Einstein formula from which was developed the nuclear energy which has revolutionized science.

mass-luminosity relation

When the absolute magnitudes of stars are plotted against the logarithms of their masses, the points lie very nearly along a smooth curve.

The curve was derived theoretically by Eddington.

It is at present valuable chiefly as a means of determining the masses of the class of stars to which it applies.

Luminosity values increase very rapidly with mass. The following are approximate average values, in terms of our sun:

Mass	*Luminosity*	*Mass*	*Luminosity*
32	3300	1	1
8	330	3/4	1/6
2	13	1/2	1/50

mass number

The atomic number (which is the number of protons, called Z) plus the number of neutrons (N) is the mass number, (called A) of the atom.

It is the total number of nucleons in the nucleus of the atom.

Mass numbers range from 1 for hydrogen to 254 for nobelium.

mass ratio

(ASTRONAUTICS) The ratio of the weight of a rocket to the weight of the fuel that it carries; it can be calculated by dividing the weight of the rocket carrying a full load by its weight when empty.

Matador

A medium-range turbojet-powered guided surface-to-surface missile of the U.S. Air Force, produced in two models: *Matador A* (equipped with a solid-propellant booster; overall length slightly less than 40 feet, body diameter 54 inches, take-off weight 12 000 lbs., thrust 4600 lbs., velocity almost Mach 1, range 600-620 miles), and *Matador B* (overall length almost 46 feet, body diameter 54 inches, take-off weight almost 14,000 lbs., velocity almost Mach 1, range over 650 miles).

mathematical astronomy

see CELESTIAL MECHANICS.

matter

The present theory is that all matter is composed of atoms of 92 naturally occurring different kinds.

The atoms are composed of smaller particles, of three important kinds, protons, electrons and neutrons, which bear electrical charges which are positive, negative and neutral, respectively.

These ultimate particles, with their electric charges, are all alike. The differences in atom of various materials depend on the number of each kind in the atom.

maximum of a variable star

The time when a variable star appears to be brightest.

maximum permissible concentration (MPC)

In radiation physics, that concentration of radioactive material in body tissue that will not produce significant injury and may be established as a limit for safe operations in industry or for experiments.

maximum permissible level or limit (MPL)

In radiation physics, the tolerable DOSE RATE (q.v.) for humans exposed to nuclear radiation. (At present, the internationally established recommendations stipulate an MPL of 0.3 roentgen per week.)

mean anomaly

The angle between the radius vector and the line of apsides of the orbit of a MEAN PLANET (q.v.).

mean distance

The average distance of a body from the focus of its orbit, i.e., the average of its greatest and least distances from it. (In the case of a binary star, the average angular separation of the two components.)

mean high tide

The average height of all high tides occurring at any place. (*see* TIDES.) Also called MEAN HIGH WATER.

mean high water

A synonym for MEAN HIGH TIDE (q.v.).

mean low tide

The average height of all low tides occurring at any place. (*see* TIDES.). Also called MEAN LOW WATER.

mean low water

A synonym for MEAN LOW TIDE (q.v.).

mean motion

The velocity with which a moving body would circle in a

circular orbit the radius of which equalled the MEAN DISTANCE (q.v.) of the body from the focus of its real orbit, during the same period of revolution as in the real orbit.

mean noon

The moment of the transit of the MEAN SUN (q.v.) across the meridian.

mean parallax

It is sometimes impossible to determine the parallax of a single star, but possible to get the average parallax of many stars.

The mean, or average, parallax of the 20 stars of the first magnitude is .06 of a second. That makes their average distance 54 light-years.

The mean parallax for sixth magnitude stars, the faintest visible to the naked eye, is .012 second, giving an average distance of 270 light years.

mean planet

An imaginary body, used for astronomical calculations, the perihelion of which coincides with the perihelion of a real planet and moves in its imaginary orbit with a uniform angular velocity which equals the mean angular velocity of the real planet.

mean sea level

see SEA LEVEL.

mean solar day

The period of time between two successive moments of MEAN NOON (q.v.).

mean solar time

see TIME.

mean sun

An imaginary sun that moves eastward on the celestial equator at a uniform rate equal to the average rate of the motion of the TRUE SUN (q.v.) in the ecliptic.

measurand transmitter

In a TELEMETERING SYSTEM, the apparatus which receives the electrical impulses from the TELEMETERING PICKUPS and processes them for transmission through the TELEMETERING LINK (q.v.).

mechanical equivalent of heat

The number of units of mechanical work equivalent to one unit of heat.

Its value depends on the units employed for both heat and mechanical energy.

777 foot pounds equals 1 British Thermal Unit, which is the heat required to raise the temperature of one pound of water one degree Fahrenheit

median magnitude of a variable star

The average of its maximum and minimum magnitudes

megaparsec

A distance of one million parsecs or 3,260,000 light years.

Used in measuring the distance to some of the external galaxies.

Megrez

The traditional name of the star δ Ursae Majoris, one of the stars in the bowl of the Big Dipper

Mensa [the Table]

A southern constellation.

Mercator projection

Representation of part of the Earth's surface by development on a cylinder tangent at the equator Meridians are parallel vertical lines. Parallels of latitude are horizontal parallel lines, the distance between successive parallels increasing with increased latitude. All rhumb lines appear as straight lines on this projection. Angles are correctly represented, but distortion o. contours and of areas increases with latitude. (*see* INVERSE MERCATOR PROJECTION.)

Mercury

The smallest of the planets. Diameter 3,100 miles.

Nearest the sun. Mean distance 35 950 000 miles. The distance varies from 28½ million to 43½ million because its orbit is the most eccentric, except for Pluto's and some of the asteroids.

Period of revolution 88 days.

Mass .04 that of the earth.

Density 3.8 that of water. The earth's density is 5.52. Mercury is the most difficult to see of all the naked-eye planets, because it never gets farther than 28° from the sun. Easiest to see in the evening in March or April. It is brighter than any star except Sirius. It twinkles because it is so small.

Ancient Greeks, Egyptians and Hindus gave it different names as morning or evening star.

Because of its small size it has no atmosphere. The velocity of escape is only 2.2 miles per second.

Its albedo is only .07, just about the same as that of the moon. Therefore its surface is supposed to be dark rock, and very rough. Faint markings have been seen, with dark areas similar to those on the moon.

Because it is so near the sun, its periods of rotation and revolution are equal, and there are no changes of day and night.

Temperatures are very high or very low. On the side where it is always day the temperature is 770°F. That is above the melting point of lead and tin. On the dark, night side it must be down to nearly absolute zero, which is—459°F.

About 13 times in a century a transit of Mercury across the face of the sun occurs. It can be seen only with a telescope.

The advance of the perihelion point of Mercury's orbit, caused by the disturbing effects of Venus and the other planets, differs by about 40 seconds a century from the predicted value. This variation was a puzzle to astronomers until

Einstein's theory of relativity said that it should occur. It is now held as one of the principal proofs of the truth of that theory.

meridian

Any of the GREAT CIRCLES (q.v.) of the earth that passes through the two poles at right angles to the equator. Meridians are the same as the HOUR CIRCLES (q.v.) for stars. Meridians of points on the earth are drawn from north to south through the zenith at the point; they will be directly over the meridian of longitude of the point. (*see* CELESTIAL MERIDIAN.)

meridian altitude

The angular elevation of a star as it crosses the meridian.

meridian angle

The arc of the celestial equator, or the angle at the celestial pole, between the upper branch of the celestial meridian of a place and the hour circle of the body, measured eastward or westward from the celestial meridian through 180° (or 12 hours), and labeled E. or W. according as the body is east or west of the celestial meridian.

meridian circle

A rather small ASTRONOMICAL TELESCOPE (q.v.), mounted on an axis pointing east-west, so that it moves in the meridian plane, i.e., can be pointed anywhere along the celestial meridian, but nowhere else. In it is a grid of vertical spider webs, so set that the middle one corresponds with the meridian. (It is also called *transit circle* or *transit meridian.*) It is used to determine the time of the passing of stars across the meridian, and hence their right ascensions.

If the time of the crossing is not the same as the known right ascension, it means that the clock is wrong The instant of meridian passage gives the correct sidereal time.

Such an instrument in the Naval Observatory in Washington is used to set the master clock from which our standard time is computed and the radio time signals sent out.

meridian of Greenwich

Positions of places on the earth are described by degrees of latitude and longitude.

By international agreement, longitude is measured east or west of the meridian which passes through the site of the Royal Observatory at Greenwich near London, England.

This is called the prime or standard meridian.

meridian instrument

Instruments designed and employed for the observation of stars as they cross the meridian.

meridian passage

A synonym for TRANSIT (q.v.–*1* and *2*).

meridian plane

The vertical plane including the zenith, the nadir and the north and south celestial poles.

meridional parts

The number of units, measured in minutes of arc, along a meridian between the equator and any latitude on a Mercator chart.

meson

A subatomic particle, heavier than an electron and lighter than a proton.

It is a short-lived phenomenon that appears to be bundle of energy. Mesons commonly result from cosmic rays, but have recently been produced in the laboratory.

mesosphere

(1) In the nomenclature of Chapman, a stratum of atmosphere sometimes called the CHEMOSPHERE (q.v.). (2) In the nomenclature of Wares, a stratum that extends approximately from 250 to 600 miles lying between the IONOSPHERE and the EXOSPHERE.

Messier catalog

A list of 103 celestial objects (star clusters and nebulae)

compiled by the French astronomer Messier and published in 1784. The numbers by which the objects are listed are referred to as *Messier numbers* and abbreviated generally as M (e.g., the Andromeda Galaxy is M31).

metagalaxy

A term designating the total recognized assemblage of galaxies, including all particles, stars, planets and star clusters that there may be in the spaces between the galaxies, so that it means essentially the entire appreciable material universe. The regions relatively nearest to us are known as the inner metagalaxy. (*see* PHOTOMETRIC RADIUS OF THE METAGALAXY)

meteor

A small body circling the sun. In interplanetary space there are millions of these bodies, of widely varying sizes. They are invisible until they come within the atmosphere of the earth, where friction with the the molecules of air heats them so that they shine.

"Shooting Stars" are tiny ones that are seen for only a moment, leave no trails, and burn up before they can reach the earth.

Fireballs are as brilliant as the bright planets or the moon, leave luminous trails that may last for several minutes.

Bolides are fireballs that explode at the ends of their paths. Fragments usually fall to the earth.

Meteorites are pieces of iron or stone that fall out of the sky: fireballs or bolides that are found after their flight.

The word "meteor" means anything that occurs in the air. but it is usually restricted to the small bodies that we see as shooting stars and fireballs.

On a clear, moonless night an observer can see an average of 10 meteors an hour. More are seen in autumn than in spring, and more in early morning than in evening. It is estimated that they fall, over the whole earth at the rate of a million an hour or 24 million a day. Many more millions every day are too faint to be seen without a telescope.

Most of them are small. An average shooting star is probably no larger than a pinhead. One the size of a golf ball may appear as bright as the full moon.

They are visible when from 45 to 90 miles above the surface of the earth.

Their velocity varies greatly. Usually from 7½ miles per second, for those that overtake the earth, to 45 or 50 miles per second for those that are coming head on.

The origin of these bodies is not known. The fastest ones may come from outside the solar system It is believed that they are material such as the planets are made of, that has not yet been added to the larger bodies—some of the planetesimals that still remain in space. (*see also* ARTIFICIAL METEOR, METEOR CRATER, METEOR SHOWER, METEOR SWARM, SPORADIC METEOR).

meteor crater

Crater on the earth caused by the fall of meteorites.

Arizona. The largest known is METEOR CRATER in Arizona. It is about 4 5 of a mile, 4,200 feet, in diameter, 570 feet deep, and its rim is 130 feet above the surrounding desert plain. Several tons of nickel-iron have been collected from the surrounding country, the largest piece weighing 1000 pounds.

Drilling in the floor of the crater, and beneath the rim, has never located a large mass of iron such as is believed to have caused the crater. Many thousands of tons of rock were melted, or blown to bits by the fall

No one knows when the fall occurred. Between 5000 and 50,000 years ago is the range of the estimates

Odessa, Texas A crater 510 feet across and 15 feet deep was discovered in 1921. The several small meteorites found there were badly rusted, which means that the fall was very long ago.

Brenham, Kansas. Nearly a ton of stony iron has been found in and near a small crater 51 feet across and 9 feet deep

South America. At Campo del Cielo in the Argentine are a

number of craters. The largest one is 225 feet across. A number of meteorites together weighing over a ton were found there.

Australia. Near Henbury are 13 craters in a group. The largest is 600 feet across and 45 feet deep. In one crater was a meteorite weighing 400 pounds.

At Boxhole is a crater 525 feet across and 40 feet deep. A meteorite found there weighed 164 lbs.

Near Delagaranga is a crater 225 feet across and 15 feet deep. Only small fragments of meteoric iron were found there in 1923.

Arabia. Near Wabar are two craters, 300 and 165 feet across. Several pieces of iron and a large amount of fused sand containing shiny, metallic globules were found there.

Estonia. On the Island of Oesel are six craters. The largest is 300 feet across and its rim is 18 feet above the ground level. It is filled with water. 28 small meteorites were found.

Siberia. On June 30, 1908 a great meteorite fell in the forest in northern Siberia. 19 years later 10 or more small craters were found, filled with water and difficult to examine. The largest one is 150 feet across No large meteorites have been found there.

It is estimated that meteorites large enough to explode and produce craters, 220 tons or more, fall at the rate of one in 150 years. Those weighing 50,000 tons, which could make craters as large as the one in Arizona, fall perhaps once in 100,000 years.

meteor shower

The brilliant celestial display visible at night when the earth encounters a dense METEOR SWARM (q.v.) in its orbit. When the swarm is approaching from the sunward direction, it is not visible at night, and is referred to as a *daytime shower*. The orbits of these meteor swarms correspond closely to those of comets, and it is believed that they are the fragments of disintegrated comets; hence certain meteor showers

are said to be "associated" with certain comets. Over 500 meteor swarms are known that produce or have produced showers. Each meteor shower is usually named for the constellation in which its RADIANT (q.v.) is located; if there is more than one radiant in any constellation, the designation of the bright star nearest to the radiant is prefixed (e.g., η Aquarids to indicate that the radiant lies near η Aquarii).

meteor stream

A METEOR SWARM (q.v.) that is strung out considerably along its orbit.

meteor swarm

A great many meteors that revolve together, they are usually strung out considerably along their orbit, and are then referred to as METEOR STREAM.

meteor trails

Fire balls leave trails in the sky that are sometimes visible for several minutes.

If the same trail is observed from two stations several miles apart, it is possible to determine the height and velocity of the meteor that caused it.

22,000 trails were studied in Arizona in 1931-33. They averaged 62 miles above the surface for meteors meeting the earth, and 48 miles for those overtaking the earth.

Their velocities vary from 44 miles per second for those meeting us, to 7½ miles for those that overtake us.

Some that seem to come in from outer space are moving much faster than this, up to 150 miles per second.

meteoric stone

see METEORITES.

meteorites

Masses of stone or iron that fall from the sky. Meteorites have been known from remote antiquity. There is a record of a fall in the Book of Joshua, chapter 10. A Chinese record tells of a fall in 687 B.C. Greek and Roman writers record 4

meteorites. In ancient times they were worshipped. It is believed that the image of Diana at Ephesus, the shield of Numa at Rome, and the image of Venus at Cyprus were meteorites. The Black Stone in the wall of the Kaaba in Mecca is a meteorite.

There are about 1000 known meteorites in museums. The oldest one seen to fall landed in Alsace on Nov. 7, 1492. They vary in weight from less than an ounce to 36½ tons.

Meteorites are classified according to their composition into three groups: AEROLITES or stony meteorites, SIDERITES or iron meteorites, and SIDEROLITES or stony-iron meteorites (q.v.), each of which is further divided into classes and subclasses according to composition and structure. Meteorites are usually covered with a thin, black crust, formed from the fused material produced by the heat of its passage through the air. Usually the surface is irregular, having depressions or pits where softer materials were melted away.

The largest meteorite known is at Grootfontein, South Africa. It weighs more than 50 tons and measures 9 by 10 feet. It is of iron and has never been moved from where it fell.

The longest one in any museum is in New York, at the Hayden Planetarium. It is of iron, 5 × 7 × 11 feet and weighs 36½ tons. It was brought from Greenland by Admiral Perry in 1895.

Stone meteorites are not so large as some of those of iron, probably because they are often broken in their fall. The largest stone fell in Kansas and weighs more than 1000 pounds. One from Arkansas weighs 750 pounds.

There is no record of any person ever having been killed by the fall of a meteorite. Two or three have been known to hit buildings, but most of them fall in the oceans or in open country.

meter-candle

A unit of illumination.

It is the illumination produced by a standard candle at a distance of one meter.

A standard candle is a 7/8 inch sperm candle burning at the rate of 120 grains per hour.

methane (CH_4)

The poison gas, called "fire damp" that sometimes kills coal miners in mine accidents.

It forms a large part of the atmospheres of the giant planets, especially Saturn, Uranus and Neptune.

metonic cycle

A period of 235 lunar months or 19 years 11 days, after which the phases of the moon repeat in the same order and on the same days. It was discovered by a Greek named Meton in 433 B.C.

It is useful in predicting eclipses and in finding the date of Easter.

Michelson-Morley experiment

An optical experiment, performed with satisfactory accuracy in 1887, to detect and demonstrate the motion of the earth through the ETHER (q.v.). The result of the experiment has been generally interpreted as disproving the existence of a physical ether.

micrometeorites

Particles of microscopic size (ranging from a few microns to not more than 100 microns, i.e., about 1/250 of one inch, in diameter) which drop on the earth from outer space; most of them are too tiny to become incandescent and vaporized during their passage through the atmosphere.

micrometer

An instrument used with a telescope, microscope or spectroscope for measuring minute distances. Very important in measuring the lines in stellar spectra.

Ring micrometer. A thin, flat ring in the focal plane of a

telescope, used especially to determine differences in right ascension and declination.

Filar micrometer. Two metal frames carrying parallel wires, or spider webs, that can be moved apart or closer together by means of screws, and very small separations accurately measured. It is used mainly for measuring the separations of double stars.

micron

A measure of wavelength equal to 1/1000 of a millimeter.
10,000 Angstroms = 1 micron.
25,400 microns = 1 inch.

Microscopium [the **Microscope**]

A southern constellation.

microsecond

One millionth of a second.

middle latitude

Two places on the same side of the equator possess a common middle latitude, one-half of the numerical sum of their latitudes. The term cannot be used in connection with points on opposite sides of the equator.

midnight culmination

The approximate date at which the center of a constellation is on the meridian at midnight.

midnight sun

The sun seen above the horizon at midnight.

This can be seen anywhere north of the arctic circle or south of the antarctic circle, on some days during the year, when the sun becomes circumpolar.

At the arctic circle the sun would be on the horizon at midnight on June 22. Farther north it would be higher in the sky, and visible at midnight for an increasing number of nights during summer. At the north pole it remains above the horizon from March 21 until Sept. 23.

The same thing is true south of the antarctic circle, but for the other part of the year, between Sept. 23 and March 21.

mile

Unit of distance. *Statute* mile: 5,280 feet, or 1,760 yards. *Nautical geographical* mile: U.S.–6,080.2 feet; Great Britain –6,080 feet; International Nautical Mile–6,076.097 feet recommended by International Hydrographic Bureau.

Milky Way

A band of cloudy light extending in a great circle around the sky. Its central line is the *galactic equator* which is inclined 62° to the celestial equator, and so placing the *galactic poles* in declination +28° and —28° respectively.

Its light is the combined light of many billions of stars.

It is never all above the horizon at one time, and so appears as an arch across the sky.

It varies from 5° to 50° in width, averaging about 20°. From Cygnus to Scorpius it is split by a long, dark lane, and in many places there are dark spots and bars. These are great clouds of obscuring matter, gas or dust, that hide the stars that are farther away. There are also bright clouds, which are huge clusters of many thousands of stars.

Many stories have been told about this cloudy pathway across the sky. For various peoples it has been the road on which the souls of the dead were passing to their future homes.

The Greeks said it was milk scattered in the sky by Juno when she was suckling the infant Hercules. They also called it dust scattered by the feet of Pegasus carrying Perseus to the rescue of Andromeda.

The Egyptians said it was grains of wheat scattered on the road to paradise.

The American Indians called it the path to the Happy Hunting Grounds, along which each soul was guided by the light of its personal star. Another Indian tribe said that long ago a horse had chased a buffalo across the sky, each kicking up a cloud of dust as it ran. Some of the way they ran in parallel

paths, where the Milky Way is divided. The horse made the brighter path of coarser dust, and the buffalo the fainter clouds of fine dust, or tiny stars. Still another Indian story tells of a huge turtle that swam across the sky, stirring up clouds of mud from the bottom (*see* GALAXY).

Mimas

A satellite of Saturn. (*see* SATELLITES OF THE SOLAR SYSTEM.)

minimum (plural: minima)

The smallest magnitude or quantity attainable in a given case.

Minimum Orbital Unmanned Satellite, Earth

see MOUSE.

minimum of a variable star

The time when a variable star appears to have the least brightness.

minitrack system

(ASTRONAUTICS) A system requiring a number of ground stations, for tracking a rocket by making use of radio waves from the rocket.

minor axis of an ellipse

The straight line that passes through the center of the ellipse perpendicularly to the MAJOR AXIS (q.v.) and ends at the circumference.

minor planets

The planets that are smaller than the Earth: Mercury, Venus, Mars and Pluto.

The term is usually used for the ASTEROIDS. Sometimes these are called PLANETOIDS.

minute

One sixtieth of an hour or of a degree.

Ptolemy, following the Babylonians, divided the circumference of a circle into 360 equal parts, and the radius into 60 cuts that were called in Latin *partes minutae primae*, (meaning

first small parts) and each of these in 60 *partes minutae secundae*, (second small parts). From these we get the words minute and second.

In measuring angles or arcs, a minute is one sixtieth of a degree.

Mira (Omicron Ceti)

The brightest, best known and first discovered of the long period variable stars; it is in the constellation Cetus, the Whale or the Sea Monster, and its astronomical name is o Ceti.

Its period averages 330 days, but varies sometimes as much as a month.

Its brightness varies from magnitude 2.2 to 10, when it is invisible to the naked eye.

It has a companion which is probably also variable.

Its spectrum is in class *M* and shows strong bands of titanium oxide.

Mira is one of the largest stars known. Its volume is 30 million times that of the sun. If the sun could be placed at its center, Mars would be inside the star

Mira-type stars

A group of more than 1300 stars having the same pattern of variability as Mira. They are all LONG PERIOD VARIABLES (q.v.).

mirage

The appearance of distant objects, seen as distorted, inverted or suspended in the sky above the apparent horizon.

It is caused by reflection by layers of air of different density, especially when the surface of the land or the sea, and the air in contact with it, is considerably warmer than the air a few yards above, making the density of the air increase upward.

Miranda

A satellite of Uranus. (*see* SATELLITES OF THE SOLAR SYSTEM.)

mirror for telescope

Mirrors are easier and cheaper to make than lenses, because only one curved surface must be ground. They can be made much larger than lenses because they can be supported on the back instead of only by the edge.

Mirrors are made of pyrex, or high-silica glass, are ground to a parabolic surface, and surfaced with either silver or aluminum. Aluminum is much better than silver because it is much more permanent. The reflecting surface is the front of the mirror. Light does not go through the glass.

missile

In general, any object thrown, dropped, hurled, projected or propelled for the purpose of making it strike a target. This definition includes all projectiles, vehicles, etc. used as weapons, whether rocket-powered, jet-powered, guided or unguided.

missile-airman

The official designation of the members of the U.S. Ballistic Missile Force, a unit assigned to the Strategic Air Command.

missilry

The science and technique of designing, launching and controlling GUIDED MISSILES (q.v.)

Mizar

The traditional proper name of ζ Ursae Majoris, the double star at the middle of the handle of the BIG DIPPER (q.v.).

Each of its components was discovered to be a spectroscopic binary, by Pickering, at Harvard, in 1889, the first spectroscopic binaries known.

modulus of distance

$m—M$, where M is the absolute magnitude of a given star, and m is its apparent magnitude. The distance of the star in parsecs, r, is given by the formula $5 \log r = m—M+5$. (Also called *distance modulus.*)

Mohammedan calendar

see CALENDAR.

molecule

A unit of matter.

The smallest portions of an element or compound that retains chemical identity with the substance.

It usually consists of two or more atoms.

Molecules of some organic compounds contain a very large number of atoms.

moment of momentum

The product of the mass of a revolving body, or system, and its distance from the center of the motion. (*see* also ANGULAR MOMENTUM, CONSERVATION OF MOMENT OF MOMENTUM.)

momentum

The product of the mass and the velocity of a moving body or system. (*see* also ANGULAR MOMENTUM, CONSERVATION OF MOMENTUM, MOMENT OF MOMENTUM.)

Monoceros [the Unicorn]

A southern constellation.

mono-fuel

(ASTRONAUTICS) A popular term for MONOPROPELLANT.

monopropellant

(ASTRONAUTICS) A PROPELLANT (q.v.) in which the fuel and the necessary oxygen are combined in one single substance. All solid propellants belong in this class, although there are also liquid monopropellants.

monopropellant rocket

A rocket equipped with a ROCKET MOTOR (q.v.) designed for a MONOPROPELLANT (q.v.).

month

The duration of one complete revolution of the moon around the earth, as measured with reference to varied data:

Anomalistic month—perigee to perigee: 27.5546 days.

Calendar month—one of the twelve divisions of the Gregorian calendar—may be 28, 29, 30 or 31 days.

Nodical month—Interval between successive similar nodes: 27.21222 days. Also called DRACONITIC MONTH.

Solar month—One twelfth of a solar year.

Sidereal month—Interval between successive conjunctions with the same star. Average 29.53059 days.

Synodic month—Interval between similar phases. Averages 29.53059 days. Also called *lunar month.* (*see* the individual entries for these months; *see* also CALENDAR.)

monthly nutation

The NUTATION (q.v.) due to the changing declination of the moon. It amounts to less than 1/10 of a second in one month.

moon

In general, a satellite. Specifically, the satellite of the Earth. Mean distance from the Earth 238,857 miles. Diameter 2160 miles.

Period of rotation and revolution 27 days 7 hrs. 43 m Actually the moon is the sixth largest satellite in the solar system. Three of Jupiter's satellites, one of Saturn's, and Neptune's satellite are larger. But compared to its planet, it is the largest of all.

Some people call the earth-moon system a double planet. It would appear so from Venus or Mars. From Venus the earth would be a blue planet brighter than Venus looks to us, and the moon would be yellow and brighter than we see Jupiter. They would be about as far apart as the diameter of the full moon.

We say the moon revolves about the earth. Actually they both revolve about their common center of mass, which is inside the earth, about 2,900 miles from its center.

Because it rotates and revolves in exactly the same time, we always see the same side of the moon.

Moonlight is only reflected sunlight. The albedo of the moon is .07, which means that it reflects only 7 percent of the light that falls on it.

The phases of the moon are due to the varying parts of the sunlit surface that we see as it revolves once each month.

The surface of the moon is very rough. The large dark areas, plainly seen, are called "Seas." They are plains, where there are no mountains. The mountain areas shine brighter because there are rock faces to reflect more sunlight.

The moon has no water and no air.

There are several mountain ranges. The longest is the Lunar Apennines, about 700 miles long, and containing peaks 20,000 feet above the plains.

There are, on our side of the moon, 30,000 craters, ranging from pits just large enough to be visible, up to Clavius, a great walled plain nearly 150 miles in diameter. The floors of some craters are several thousands of feet below the plains outside, and their walls have peaks nearly 4 miles above the floor.

The craters are believed to be of volcanic origin, although possibly, some are meteoric.

Because of the absence of an atmosphere, sunlight on the moon is very bright and shadows are absolutely black. There can be no twilight and no shade.

Temperatures are very severe. Near the equator at noontime the rocks would be above the temperature of boiling water, 212°F. At midnight it is —200°F.

Surface gravity is 1/6 of that on the earth. A 150-pound man would weigh 25 pounds on the moon.

Eclipses of the sun are caused by the moon passing between the earth and the sun and casting a shadow that extends to the earth.

Eclipses of the moon are seen when the moon passes through the shadow of the earth. (*see* ECLIPSE OF THE MOON, LIBRATIONS OF THE MOON, MOUNTAINS ON THE MOON, SATEL-

LITES OF THE SOLAR SYSTEM; cf. also the entries beginning with the word LUNAR.)

moon dogs

see SUN DOGS AND MOON DOGS.

moon messenger

(ASTRONAUTICS) A designation of planned unmanned rockets to the moon, intended to make only a one-way trip, without ever returning.

Moonwatch

The world-wide volunteer visual satellite observing program of the Smithsonian Astrophysical Observatory.

morning star

The designation applied to a naked-eye planet when it rises before the sun; it is a misnomer, since the body concerned is not a star at all.

motion

Movement of an object in the celestial sphere. It may be DIRECT MOTION (when the object moves eastward among the stars) or RETROGRADE MOTION (qq.v.) when the object moves westward among the stars). *see* also LAWS OF MOTION, PARALLACTIC MOTIONS OF STARS, PECULIAR MOTION OF A STAR, PREFERENTIAL MOTIONS OF STARS, PROPER MOTION, RELATIVE MOTION, RADIAL MOTION, SOLAR MOTIONS, TANGENTIAL MOTION.

motus parallacticus

Latin for PARALLACTIC MOTION (q.v.).

motus peculiaris

Latin for PECULIAR MOTION (q.v.).

mountains of the Sun

see SOLAR MOUNTAINS.

mountains on the Moon

Galileo in 1610 was the first man who ever saw mountains

on the moon, although Plutarch and others appear to have believed that they were there.

There are very high, single peaks, standing on the plains without surrounding foothills.

There are three well known mountain ranges, the Apennines, Caucasus, and the Alps, named by Hevelius in 1647. The Apennines is the longest range, about 700 miles. They rise very abruptly from the plain on one side, and slope gradually on the other. There are thousands of peaks, some 20,000 feet high. The highest peaks are near the south pole and reach 26,000 feet.

Heights are measured above the plains, since there is no "sea level."

mounting of telescope

see TELESCOPE.

MOUSE

The "*M*inimum *O*rbital *U*nmanned *S*atellite, *E*arth," a proposed artificial satellite, intended for study of the upper layers of the atmosphere and of the ultraviolet and x-ray emission of the sun. A sphere 1 foot in diameter, capable of carrying about 45 pounds of scientific equipment, planned to circle the earth at an altitude of about 200 miles in a polar orbit, completing a revolution in approximately 90 minutes.

moving cluster

A group of stars, usually a considerable number, moving in the same direction. A well known moving cluster consists of 126 stars, including Sirius, α Coronae, β Aurigae and five of the stars of the Big Dipper (the ones at the tip of the "bowl" and the end of the "handle" are the two not included); our sun is in this cluster now, but is not a member of it, just happens to be passing through it. In Taurus there is another well known moving cluster of 360 stars

MPC

Abbreviation for MAXIMUM PERMISSIBLE CONCENTRATION (q.v.).

MPL

Abbreviation for MAXIMUM PERMISSIBLE LEVEL OF LIMIT (q.v.).

multiple star

A system of three or more stars that appear as a single star to the naked eye. (Cf. DOUBLE STAR.) For instance, Castor is a triple star, and all three are spectroscopic binaries, so there are six stars.

The double-double in Lyra is two pairs of stars, and one of the four is a spectroscopic binary.

There is a quadruple system in Cancer. The pairs revolve in 18 and 60 years, at distances equal to those of Jupiter and Uranus from the sun, and both go around a common center in about a thousand years, at about the distance of Pluto.

multiplets

Groups of related lines found in some complex star spectra.

multi-stage rocket

A STEP ROCKET (q.v.) consisting of more than two steps or stages.

Musca [the Fly]

A southern constellation. Also referred to as *Musca Australis*, the *Southern Fly*.

N

nadir

The point on the celestial sphere that is diametrically opposite the zenith, so that the zenith, nadir and center of the earth are in one straight line. It is always 90° below the horizon.

naked-eye star, planet, etc.

A star, planet, etc. visible with the unaided eye.

natural radioactivity

The radioactivity associated with the naturally occurring heavy elements.

Nautical Almanac and Ephemeris

An annual publication, issued three years in advance, giving tables showing the positions of the sun, moon and other heavenly bodies, and other data of importance to astronomers and navigators. Published by the U.S. Naval observatory and the Government Printing Office.

Such almanacs are prepared by a number of governments.

They contain also ephemerides which give the right ascension and declination of the sun, moon and planets at regular intervals of time, and also of a large number of "clock stars," which are observed for the determination of time.

There are also predictions of eclipses, occultations and other phenomena.

nautical astronomy

That branch of PRACTICAL ASTRONOMY (q.v.) which con-

sists of the art of determining the position of a ship and solving problems of direction on the earth's surface by the aid of celestial objects, i.e., by the application of the principles of astronomy.

nautical mile

The length of one minute of arc of a great circle on a sphere having the same area as the earth. This length is 6080.20 feet, or approximately 38/33 of a statute mile.

nautical twilight

The period before sunrise or after sunset during which the center of the sun is not more than 12° below the horizon. (*see* TWILIGHT.)

Navaho

A winged, supersonic, guided, surface-to-surface intercontinental missile of the U.S. Air Force, propelled by two ramjet engines, with booster rocket for the take-off; it has a speed of 1900 m.p.h. and a range of 5000 miles.

navigation

The art and technique of determining the position of a ship at any time and conducting the ship from one position to another. The problems of navigation are those of position, direction and distance.

navigational planets

The planets most used for obtaining lines of position: Venus, Mars, Jupiter and Saturn. (Mercury is too near the sun, and the other planets are not bright enough.)

navigational triangle

Spherical triangle solved in computing altitude and azimuth of a celestial body. (*see* ASTRONOMICAL TRIANGLE.)

neap tides

Tides that occur near the times of first and third quarters of the moon, when the tidal effects of the moon and sun op-

pose each other, and high tides are lower and low tides are higher than average. (*see* TIDES.)

nearest stars

There are 22 stars having a parallax greater than .255 of a second, and so within 13 light years of the earth. Only 7 of these are bright enough to be seen with the naked eye, and of the seven, only Sirius and Procyon are easily seen from the United States.

nebula (plural: nebulae)

Vast aggregations of matter at stellar distances, that show as hazy spots or clouds, and many of which can not be resolved into their components. They are divided into two main classes: I) *Galactic nebulae*, so named because they are in or near our galactic system and can well be assumed to belong to it. II) *Extragalactic nebulae*, which are all over the visible universe *outside* our galactic system, and are recognized today as external galaxies. The *galactic nebulae* are *bright* (those that are made luminous by stars in their vicinities) or *dark* (or obscure) *nebulae* (which can be recognized solely by optical means owing to their obscuring effect on the stars behind them). They are divided into two subgroups: (1) *Diffuse nebulae* and (2) *planetary nebulae*.

nebular hypothesis

A theory of the origin and early history of the solar system, proposed by Laplace, a French mathematician, in 1796.

He began with the sun already formed and surrounded by an extensive nebulous atmosphere which was hot, and in slow rotation. As it cooled it contracted, and so rotated faster. Increased speed caused greater flattening at the poles, and bulging at the equator. When the centrifugal effect became equal to the gravity, a ring of gas was abandoned and the central mass went on contracting and leaving rings behind. Each ring broke and assembled into a gaseous planet whose orbit was the same as the ring from which it was formed.

Most of the planets, as they cooled, left rings behind from which their satellites were formed. The rings of Saturn seemed to support this theory.

Laplace supposed that the sun and the stars had been formed by the concentration of very large and diffuse clouds of nebulous matter.

This hypothesis is no longer accepted.

nebular lines

The red, green, blue and ultraviolet spectral colors of the glow of BRIGHT NEBULAE (q.v.), formerly assumed to be produced by a hypothetical substance named *nebulium*; they are now known to come from such common substances as oxygen, nitrogen and neon that have lost many electrons.

nebulium

The hypothetical substance formerly thought to be the source of the NEBULAR LINES (q.v.); its existence has been definitely disproved.

nebulosity

A general term for a hazy glow or patch of luminosity seen through telescopes. (*see* EMISSION NEBULOSITIES, also NEBULA.)

nebulous

Hazy or cloudy.

nebulous cluster

A cluster of stars so far away that it has a hazy, cloudy appearance like a nebula. The Praesepe in Cancer is nebulous to the naked eye, but not in a telescope.

nebulous star

A designation applied to a small class of stars which have large, gaseous atmospheres and therefore have a hazy appearance.

negative acceleration

A synonym occasionally used for *deceleration*, i.e., retarda-

tion or loss of velocity, either spontaneous or deliberately induced.

negative eyepiece

An EYEPIECE (q.v.) consisting of two plano-convex lenses, so arranged that the plane surface of each faces the eye of the viewer. The focal length of the larger lens (the *field lens*) is approximately three times that of the smaller one (the *eye lens*), and the image is formed between them.

Neptune

The planet that was discovered by mathematics. Long repeated observations of the motions of Uranus seemed to prove that it was perturbed in its orbit by the attraction of another planet beyond it.

Leverrier in France, and Adams in England, in 1846, independently worked out the position of such a planet and told the astronomers where to point their telescopes. The planet was first seen by Galle at the Berlin Observatory.

Distance from the sun 2,793 million miles, 30 times the distance of the earth.

Diameter 31,000 miles. Called the twin of Uranus.

Period of revolution 165 years.

Period of rotation 15 hours 48 minutes.

Mass 17.2 times that of the earth.

Density 1.58 times that of water.

Neptune has two satellites, one about 3,000 miles in diameter, which is 220,000 miles from the planet and revolves in 5 days 21 hours, in a retrograde direction; the other, discovered in 1949, has a diameter of about 200 miles, and its period is about one year.

No surface markings have ever been seen.

Neptune has an atmosphere, almost entirely of methane with only a trace of ammonia.

Sunlight would be pretty faint on Neptune, with the highest surface temperature about —330° F Oxygen and nitrogen would be frozen at this temperature.

Nereid

A satellite of Neptune. (*see* SATELLITES OF THE SOLAR SYSTEM.)

neutral point

(ASTRONAUTICS) That point on the imaginary line joining two celestial bodies at which their gravitational fields balance each other exactly.

neutron

One of the heavy particles contained in the nucleus of an atom.

It is of about the same weight as a proton, 1.008930, but it carries no electrical charge: it is electrically neutral.

New General Catalogue of Nebulae and Clusters of Stars

see NOMENCLATURE OF NEBULAE AND STAR CLUSTERS.

new moon

The phase of the moon when it is in CONJUNCTION (q.v.) and its dark side is turned toward the earth, so that it is invisible. (*see* PHASES.)

new star

see NOVA.

Newton's universal laws of motion

Laws governing all motion, including that of planets, formulated by Isaac Newton in 1687.

(1) Every body continues in a state of rest or of uniform motion in a straight line unless acted upon by a force.

(2) When a body is acted upon by a force, its acceleration is directly proportional to the force and inversely proportional to the mass of the body, and the acceleration takes place in the direction in which the force acts.

(3) To every action there is always an equal and opposite reaction.

Newtonian telescope

A type of REFLECTING TELESCOPE (q.v.) invented by New-

ton, in which the object is viewed through an EYEPIECE (q.v.) set in the side of the tube containing the apparatus; the incident light is reflected by the main mirror and deflected into the eyepiece by a small plane mirror placed on the axis of the telescope just inside the principal focus, and inclined at an angle of 45° to the axis. *Newton's Law of Universal Gravitation* (*see* GRAVITATION).

N.G.C.

The abbreviation for the *New General Catalogue of Nebulae and Clusters of Stars* (*see* NOMENCLATURE OF NEBULAE AND STAR CLUSTERS).

Nicol prism

A long, narrow block of Iceland spar, consisting of two parts cemented together, through which light is sent lengthwise. It transmits only that part of the light which is polarized in the principal plane of the prism.

night effect

Broadening and shifting of the minimum of a radio direction finder at night, particularly marked near the time of sunrise or sunset.

nightglow

see AIRGLOW.

Nike-Ajax

A short-range (18-23 miles) supersonic guided antiaircraft missile of the U.S. Army, formerly called *Nike* and later *Nike-A*. Liquid-propellant operated with solid-propellant booster rocket. Overall length, with booster, 35 feet, body diameter 12 inches. Take-off weight (not including the booster) about 1500 lbs.

Nike-Hercules

An advanced version of the NIKE-AJAX missile (q.v.).

Nike-Zeus

A supersonic guided antiaircraft missile of the U.S. Army,

a further improved version of the NIKE-AJAX and NIKE-HERCULES (q.v.), still in the developmental stage.

nocturnal

A small instrument, something like an astrolabe, used for telling time at night by observation of the stars.

nodes (of the Moon's orbit)

Because the moon's orbit is inclined about 5° to the plane of the ecliptic, it must pass through that plane at two points. These are the nodes.

Ascending node is where the moon crosses the ecliptic from south to north.

Descending node is where the moon crosses from north to south.

The attraction of the sun for the moon causes the nodes to shift westward or to regress along the ecliptic, completing one revolution in about 18.6 years.

Eclipses occur only when both sun and moon are at or near one of the nodes. Planetary orbits have similar nodes. (*see* REGRESSION OF NODES.)

nodes of the planets (of the planetary orbits)

The points at which the orbits of the planets intersect the ecliptic, because of the inclination of their planes to the plane of the earth's orbit. (Cf. NODES.)

nodical month

The period of time required by the revolution of the moon around the earth, from one of its nodes to the same node. Its length is 27.21222 days (i.e., 27 days 5 hours). It is called also *Draconitic month.*

noise

In radio astronomy, the terms "noise" and "radio noise" are used to designate electrical energy with a spectrum that is essentially a continuous one, in contradistinction to the discrete frequencies of the radio signals. (*see* GALACTIC NOISE, SOLAR NOISE.)

noise storm

Allen's Term for a phenomenon in the radio emission of the sun, consisting of a long series of BURSTS (q.v.) or prolonged enhancement in intensity.

nomenclature of artificial satellites

A suggestion of the Smithsonian Astrophysical Observatory, approved by the I. G. Y. that the system of nomenclature adopted for artificial satellites be analogous with that in use for naming newly discovered comets That is, the satellites are designated by the number of the year of launching and sighting, followed by a Greek letter (assigned in the usual Greek alphabetic order), if more than one object are assigned the same Greek letter (i e , in the case of a group of objects launched together), a Roman numeral is appended, assigned in order of brightness, the brightest of the objects being designated as 1. Thus, *Satellite 1957α1* is the third stage of the rocket that launched the 1st Russian satellite (commonly known as Sputnik I), and *Satellite 1957α2* is Sputnik I itself *Satellite 1957 β* is the second Russian satellite (Sputnik II). Explorer I is 1958 α.

nomenclature of comets

Newly discovered comets are designated temporarily by a letter assigned to them in alphabetical sequence and in the order of the discovery, the first one discovered in any one year being given the letter *a*, the second one the letter *b*, etc.; the letter is preceded by the number of the year and followed, in parentheses, by the name of the discoverer. After the computation of the orbits, of new comets and the determination of the perihelion passage, the letters are replaced by Roman numerals in the order of the times of perihelion the first comet to pass perihelion in the given year being designated as I.

nomenclature of nebulae and star clusters

The two standard catalogs of these objects are: (*a*) the

catalog of 103 nebulae and clusters published by Messier in 1784, and (*b*) the *New General Catalogue* of Dreyer, published in 1888. A nebula or cluster is known by its number in either of these catalogs, preceded by M in the case of Messier's catalog, and by NGC in the case of Dreyer's New General Catalogue; e.g., M81, NGC 4254, etc.

nomenclature of stars

The brighter stars of each constellation are designated by a Greek letter followed by the name of the constellation in the genitive case. Thus, e.g., the brightest star in Orion is called α (*alpha*) *Orionis*. When all the letters of the Greek alphabet have been used up in any one constellation, its remaining stars are designated by lower case Roman letters (Bayer letters) and numbers (Flamstead numbers). Variable stars are designated by capital Roman letters from R to Z (e.g., R Andromedae), followed by the double-letter combinations RR, RS . . . RZ, SS, ST . . . SZ, TT . . . ZZ (e.g., SU Cassiopeiae), further by AA, AB . . . AZ, BB . . . BZ, etc., to QZ, and thereafter by numbers appended to the capital letter V, the variable named immediately after using the combination QZ being V335 followed by V336, etc. Hundreds of stars have traditional proper names given them by ancient Greek, Roman and Arabic as well as medieval and early modern astronomers and astrologers, and many of these names are still in current use (e.g., *Sirius* for α Canis Majoris, *Arcturus* for α Boötis, *Capella* for α Aurigae, etc.).

Nonagesimal Degree

The 90th degree of the ecliptic reckoned from the horizon. The middle or higher point of that half of the ecliptic which is at any given time above (or below) the horizon.

noon

Midday; the moment when the sun is on the meridian. (*see* APPARENT NOON, MEAN NOON, SIDEREAL NOON.)

noon-mark

A line drawn exactly north and south, with a plumb-line or some vertical edge, such as the edge of a door frame or a window sash, at its southern end.

The shadow will always fall upon this line at local apparent noon.

Norma [the Rule]

A southern constellation.

normal atom

An atom in its ground state, that is, without any extra energy, is said to be a normal atom. An atom that is not in an excited state.

normal spiral

The designation of a *spiral galaxy* that has a lens-shaped central portion with two arms which begin to coil in the same plane and in the same fashion immediately upon emerging from it. Normal spirals are divided into three classes according to the shapes and structures of the central portion and of the arms: *Class Sa* comprises the spirals that have the largest central portions and thin arms that are very close to it; *Class Sb* spirals have smaller central bodies with larger, more open arms, *Class Sc* contains the spirals with the smallest central portions and the largest and most loosely coiled arms. Class *Sa* and *Sb* spirals are chiefly Population II types, except for their arms which are Population I, Class *Sc* formations are generally Population I (*see* STELLAR POPULATIONS).

north

The opposite of south, i.e., that one of the cardinal points of the compass that lies in the plane of the meridian, and on the left hand of a person facing due east.

north point of the horizon

That point of intersection of the meridian and horizon that is nearer the north pole.

north polar sequence

see SEQUENCE METHOD.

North Star

see POLARIS.

Northern Cross

see CYGNUS.

Northern Crown

see CORONA BOREALIS.

Northern Lights

see AURORA.

northing

North declination. The difference in latitude toward the north from the last preceding point of reckoning.

Before navigators were able to measure longitude, they crossed the Atlantic by doing their "northing" or "southing" first. That is they sailed due east or west until they reached the shore. They could measure latitude by observing the height of the North Star.

nose cone

(ASTRONAUTICS) The foremost section of a rocket or missile, usually housing scientific instruments, or test animals, or explosives, etc.

nova (plural: novae)

A VARIABLE STAR (q.v.), the brightness of which increases in a sudden, intense outburst to tens or hundreds of thousands, often millions, of times its original intensity; the stage of maximum brilliance does not last long and is followed by a decrease in brightness until the star has reverted to its original luminosity in the course of a period ranging from one year to thirty years. (Novae are divided into two broad classes, *fast* and *slow* novae, according to the length of time required for the final increase in their brightness after the abrupt initial outburst of brilliance and for the subsequent decline in mag-

nitude.) The spectroscopic phenomena following the initial outburst seem to be best accounted for as produced by shells of gas moving outward from the star at enormous velocities that reach hundreds of miles a second. Novae are referred to also as *temporary stars.* Between 10 and 20 appear in our galaxy every year. A few exceptionally bright ones, called SUPERNOVAE (q.v.), are 10-100 million times as bright as our sun. (*see also* KEPLER'S STAR, RECURRENT NOVA, TYCHO'S STAR.)

Nubeculae

An old name for the MAGELLANIC CLOUDS (q.v.).

The larger cloud was called the *Nubecula Major,* and the smaller cloud was *Nubecula Minor.*

nuclear energy

The energy in the atomic nuclei, which is released in nuclear fission or other suitable nuclear reactions. The fission of the nucleus of every atom in 1 gram atomic weight of the uranium isotope U^{235} would release about 5 300 000 kilowatt-hours of energy.

nuclear fission

The splitting of atomic nuclei into two fragments of more or less equal mass, either as a spontaneous process or induced artificially.

nuclear propellant

(ASTRONAUTICS) A PROPELLANT (q.v.) which supplies power derived from controlled nuclear fission.

nuclear reaction

Any induced nuclear DISINTEGRATION (q.v.), produced directly or indirectly by exposure to or bombardment by radiation or elementary particles or another nucleus. (*see* THERMONUCLEAR REACTION.)

nuclear reactor

An apparatus designed and operated to maintain a self-

supporting chain reaction of nuclear fission in a suitable material.

nuclear transmutations

Changes which affect the structure of the nuclei of atoms.

There are two kinds: (1) Those which involve a single nucleus, like the spontaneous disintegration of radium to lead. (2) Those in which two nuclei unite to form a single nucleus of more complex structure, with the liberation of α, β or γ rays. An atom of $_3Li^7$ unites with one of $_1H^1$ and forms one $_4Be^8$ with one γ ray; or they may form two $_2He^4$.

nucleus

(1) The small, brighter, denser portion of a comet.

(2) The central portion of an atom.

nutation

Irregularity in the precessional motion of the equinoxes resulting from the constantly varying positions of the moon and other celestial objects north or south of the ecliptic.

The attractions of the sun and moon on the earth's equatorial bulge cause the motion of precession. Because it is nearer, the moon has twice as great an effect as the sun. Also the moon's orbit is inclined 5° to the ecliptic, and its nodes slip around the ecliptic in 19 years.

Therefore once in 19 years the celestial pole completes a small ellipse around its average position. This irregular wavy motion of the pole is called nutation.

The *lunar nutation* is due to the motion of the moon's nodes. It amounts to 9.2 seconds in a period of 19 years.

The *solar nutation* is due to changing declination of the sun. It amounts to 1.2 seconds in a period of one year.

The *monthly nutation* is due to changing declination of the moon. Less than .1 second in a month.

O

Oberon

A satellite of Uranus. (*see* SATELLITES OF THE SOLAR SYSTEM.)

object glass

see OBJECTIVE.

objective

That part of a telescope that gathers and focuses the light to form an image, for viewing by means of the EYEPIECE (q.v.). (Also called *object glass.*) It may be a lens or system of lenses, a mirror or a mirror system. (Many authors restrict the use of the term to the lens of a refracting telescope, and use the word *primary* to refer to the mirror of a reflecting telescope.)

objective grating

A grating made of parallel wires placed over the objective lens of a telescope.

When stars are photographed through it, each star makes a strong central image flanked by several weaker, diffraction images in a line at right angles to the wires, whose relative brightness can be calculated.

This is used in getting the photographic magnitudes of the stars.

objective prism

A large prism, usually of small ang. placed in front of the

objective of a photographic telescope, which thus becomes a spectroscope without a slit or a collimator.

oblate

Flattened at the poles.

oblate spheroid

A solid formed by rotation of an ellipse about its minor axis.

A body that is of the shape of the earth.

The planets are nearly all flattened at the poles. Jupiter and Saturn are much more oblate than the earth.

oblateness

The flattening of a spheroid; it is the ratio of the difference between the equatorial and polar diameter to the equatorial diameter.

oblique sphere

The CELESTIAL SPHERE (q.v.) as it appears to an observer between the equator and a pole, where celestial objects appear to rise and set obliquely to the horizon. The angle that their paths make with the horizon is the complement of the latitude.

obliquity of the ecliptic

The angle between the planes of the earth's equator and of the ecliptic.

Its mean value is about 23°26′54″ and it is decreasing at the rate of .47″ per year. This will continue for about 15,000 years, when it will begin to increase. It will never vary more than 1½° on each side of the mean.

obscure nebulae

DARK NEBULAE (q.v.).

observational astronomy

That branch of ASTRONOMY (q.v.) which is concerned with the instruments (telescopes, cameras, spectroscopes, etc.) their uses, and the records made by the observers with their aid.

observational twilight

Evening or morning period during which the sun is less than 10° below the horizon. (*see* TWILIGHT.)

observatory, astronomical

A building erected and equipped for the observation and study of celestial bodies.

observed altitude

The sextant altitude plus or minus corrections, such as the corrections for INDEX ERROR, REFRACTION, DIP, SEMIDIAMETER, PARALLAX and CORIOLIS EFFECT (q.v.).

occultation

The hiding of one heavenly body by another, apparently much larger, as when the moon passes between us and a star, or when one of the moons of Jupiter or Saturn passes behind the planet.

octant

An instrument for measuring angles, constructed on the same principle as a sextant, but embracing one-eighth of a circle, i.e., 45°. (The term is used to designate also the position of a celestial body when it is half-way between conjunction and quadrature, or the position when a body is separated from another by 45°.)

old moon in the new moon's arms

The reflection of earthlight from the dark portion of the moon when it is in the crescent phases. (*see* EARTHSHINE.)

onboard guidance

Automatic steering controls on guided missiles and unmanned space ships. Also known as airborne or inflight guidance.

opacity

Opaqueness, inability to transmit light.

open cluster

see STAR CLUSTER.

Operation Farside

A series of experiments in which rockets are carried high into the stratosphere by means of Skyhook balloons and then fired. The sixth in this series was fired from an altitude of 100,000 feet on October 21, 1957, and reached a height of 4,000 miles. The rocket was a four-stage SOLID PROPELLANT ROCKET weighing 1900 pounds and carrying a 3½ pound instrument package.

Operation Moonwatch

Code name of the volunteer program for visual tracking of the artificial satellites launched during the International Geophysical Year (1957-1958). Under the supervision of the Smithsonian Astrophysical Observatory.

Operation Vanguard

A designation of the official U.S. artificial earth satellite program. (*see* U.S. ARTIFICIAL SATELLITE, VANGUARD.)

Ophiuchus [the Serpent Bearer]

A large constellation, with only one second magnitude star, south of Hercules and north of Scorpius.

It represents an old man holding a large snake that coils about him and between his legs.

The Greeks called it Aesculapius, the god of medicine.

The figure is drawn with one foot on the Scorpion, as Hercules has his foot on the head of the Dragon.

The head of the serpent is an X of five small stars near the Northern Crown, and the long, curved line of stars is very easily traced.

Most books list Serpens (the Serpent) as a separate constellation.

None of the stars in either is of particular interest or importance.

opposite tides

The tides on the opposite side of the earth from the sun or

the moon. They are a trifle lower than direct tides because of the greater distance from the tide raising body.

opposition

Two bodies are in opposition when their difference in celestial longitude is 180°.

The moon is in opposition with the sun when it is full. It is then in the opposite side of the sky.

A planet is in opposition when it is on the opposite side of the earth from the sun.

optical binary

see OPTICAL DOUBLE STAR.

optical double star

Two stars that appear to the naked eye as one single star merely because they lie almost on the same straight line to the eye of the observer, without necessarily being close together or being an actual physical double star or a BINARY (q.v.).

optical interferometer

see INTERFEROMETER.

optical window

see ATMOSPHERIC WINDOWS.

orbit

The path in which one body revolves about another under the gravitational attraction of the latter, as a planet or comet around the sun, or a satellite around a planet. (*see* ELEMENTS OF PLANETARY ORBITS.)

orbital decay

(ASTRONAUTICS) The lessening of the eccentricity of the elliptical orbit of an artificial satellite, in that the APOGEE (q.v.) of every revolution is slightly closer to the earth, until the ellipse becomes a circle, which decays further into a spiral

path that brings the satellite into denser atmospheric strata where the friction-produced heat will vaporize it. (This vaporization by the aerodynamically generated heat is called the *burn-up.*)

Orbital Nodes

Points in an orbit where it crosses the plane of the ecliptic or the equator.

orbital period

The length of time required by a celestial body to complete a revolution about its primary. In *astronautics*, the term is applied analogously to the time required by an ORBITAL ROCKET or ARTIFICIAL SATELLITE (q.v.) to circle the earth (or another celestial body).

orbital refueling

(ASTRONAUTICS) The replenishment of the supply of propellant of a rocket circling in a closed orbit.

orbital rocket

(ASTRONAUTICS) An unmanned rocket placed in an orbit about the earth, to serve as a temporary artificial satellite.

orbital velocity

(1) The velocity with which a body moves in an orbit. (2) (ASTRONAUTICS) The velocity which enables a rocket to rise to an altitude sufficient to take up an orbit around the earth and to circle in it indefinitely, but without attaining sufficient velocity to ESCAPE (q.v.) from the earth's gravitational attraction. (Also called *circular orbital velocity.*) Orbital velocity on the Earth is 18,000 miles per hour.

orbiter

(ASTRONAUTICS) A familiar generic term for ORBITAL ROCKETS (q.v.) and all artificial satellites in general.

orbiting

(ASTRONAUTICS) Movement in an orbit.

orientation

The placing of a building in any determined relation to the points of the compass.

Egyptian temples were oriented to the rising points of certain stars, so that the light of the star, at its rising, would shine through the entrance and upon the altar. Several temples were oriented to the sunrise at the equinox or the solstice; temples of Isis were oriented to the heliacal rising of Sirius (of which star Isis was regarded as the personification), and for temples of other gods other stars (e.g., Capella, Canopus, γ Draconis) were used. The dates of the construction of such temples can be determined by calculating when these stars must have risen in the proper places to shine into these temples.

orientation

(ASTRONAUTICS) Determination or awareness of one's position in relation to other objects.

Orion [the **Hunter**]

One of the most beautiful and best known of all the constellations. It represents a giant hunter and is in our evening sky from November until May.

It contains two first magnitude stars and four-second magnitude.

Betelgeuse is a deep orange, and the third largest star ever measured. Its diameter varies from 300 to 480 times that of the sun, which makes its volume nearly 30 million times the sun's. Its mass however is only 50 times the sun's mass, so that its density is very low. It is 240 light years away from us.

Rigel, in the left foot, is the 7th brightest star in the sky, but in absolute magnitude it is second only to Canopus. It gives 14,000 times as much light as the sun, but is 460 light-years away.

The three stars in the belt, Mintaka, Alnilam, and Alnitak,

are beautiful matched second magnitude stars. The northern one, Mintaka, is almost exactly on the celestial equator. The line joining them is just 3° long.

The middle star of the three in the sword is the largest and brightest of the gaseous nebulae. It is 2,000 times as wide as the solar system and about 1,200 light-years away.

Orion stars (Orion-type stars)

The Class *B* stars (*see* SPECTRAL CLASSES).

Orionids

A meteor shower, the RADIANT (q.v.) of which lies in the constellation Orion; seen in October, with about 20 swift meteor streaks visible every hour at the time of its maximum (October 18-20).

orrery

An apparatus which illustrates the relative positions and motions of bodies in the solar system, by the rotation and revolution of balls moved by wheelwork.

It was named for Charles Boyle the 4th Earl of Orrery who had a very fine one at his castle about 1725.

Such an apparatus used to be called a planetarium

oscilloscope

Face of the screen of a cathode ray tube on which the information received by certain electronic instruments is presented visually. On a radar scope a horizontal line or trace appears with an upward deflection or pip and another for the echo. The distance between pips is proportional to the distance. The bearing of the antenna of the transmitter can be noted at any instant, making it possible to read the direction and distance of a target from the observer.

osculating orbit

The orbit which a body, usually a comet or an asteroid would pursue if, at a specified instant, all the planets were

annihilated and it moved thereafter under the attraction of the sun alone.

outer planets

The five planets farthest from the Sun: Jupiter, Saturn, Uranus, Neptune, Pluto.

outer space

(ASTRONAUTICS) A general term for any area or region beyond the atmospheric envelope of the earth. (*see* DEEP SPACE.)

overexposure

Exposure to radiation beyond the specified, recommended or safe limits.

Too long a photographic exposure to achieve optimum results.

overluminous

Said of a star that radiates more light than a MAIN-SEQUENCE (q.v.) star of its mass would be expected to be radiating according to the MASS-LUMINOSITY RELATION (q.v.).

oxidizer

(ASTRONAUTICS) Any substance that supplies the oxygen necessary for the burning of the rocket PROPELLANT (q.v.).

oxygen

A chemical element that occurs as a gas under ordinary terrestrial conditions, but can be liquefied under normal pressure at the temperature of —183°C. Gaseous oxygen forms about one-fifth of the atmosphere of the earth and is essential for the sustenance of life as we know it. Liquefied oxygen is frequently used as an oxidizer in rocket motors.

ozone

An allotropic form of oxygen, an important constituent of the STRATOSPHERE, formed from atmospheric oxygen by the effect of ultraviolet radiation.

ozone layer

see OZONOSPHERE.

ozonosphere

A stratum in the upper stratosphere at an altitude of approximately 40 miles having a relatively high concentration of ozone and important for its absorption of ultraviolet radiation from the sun.

P

pad

(ASTRONAUTICS) A thick, massive concrete base which supports a rocket or missile intended to be launched.

Pallas

see ASTEROIDS.

parabola

A CONIC SECTION (q.v.): the open curve formed by cutting a cone by a plane parallel to a sloping side of the cone.

Its eccentricity equals 1. It extends an indefinite distance, and its two ends approach parallelism.

The orbits of many comets are nearly parabolic.

All parabolas, like all circles, have the same form, but not the same size.

parabolic reflector aerial

A directional aerial used in radio astronomy, characterized by the use of a small aerial at the focus of a parabolic reflector; changes in the wavelength and in the direction of the beam can be achieved readily by alteration of the small aerial.

parabolic velocity

A velocity great enough to cause a revolving body to change from an elliptical to a parabolic orbit.

The speed of the earth in its orbit is 18½ miles a second. If this could be multiplied by 1.41, which is the square root of 2, and so become 26 miles a second, its orbit would be

a parabola, and it would depart from the sun and never return. Usually referred to as *velocity of escape*. (The term in universal use in astronautics is *escape velocity*.)

parallactic angle

The angle formed at a celestial body by the arcs of two great circles, one of which passes through the body and the celestial pole, the other through the body and the zenith. (*see* PARALLAX.)

parallactic ellipse

The ellipse of the orbital motion of the earth causes every star to appear to describe an ellipse on the celestial sphere about its mean position once every year; the semimajor axis of this ellipse is the PARALLAX (q.v.) of the star in question.

parallactic motions of stars

The stars appear to be drifting away from the point on the celestial sphere toward which the sun is moving, the APEX OF THE SUN'S WAY (q v.), and closing in toward the opposite point, the ANTAPEX (q.v.).

The parallactic motion is the motion toward or from the apex of the sun's way.

parallactic shift .

The apparent shift in the position of a star owing to the change in the position of the observer. (*see* PARALLAX.)

parallax

The apparent difference in the position of a celestial body when viewed from different positions. The simplest example is the apparent shift of an object against a distant background when viewed first with the right eye alone and then with the left eye alone. The parallax of a star is the angle subtended at the star by the mean radius of the orbit of the earth.

An engineer measures the width of a river, by drawing a

carefully measured base line on his side, and measuring the direction of an object on the other side from the two ends of the line. He can then construct a triangle and compute the distance from the base line to the object.

An astronomer measures the distance to the moon in the same way; he measures the direction from two distant observatories at the same time, or from one observatory at different times and calculates how far the turning of the earth has carried him in the given time. If his observations are 6 hours apart, his change of position is equal to the radius of the earth. That is his base line.

To measure the distance to a star, no base line on the earth is long enough. The base used is the diameter of the earth's orbit, 186,000,000 miles. Two observations of the star are made six months apart.

The parallax of the star is one half of the angle measured from these two observations, or the difference in position of the star as measured from the earth and from the sun. It is the angle at the star, subtended by the radius of the earth's orbit. This is called *heliocentric* or *annual parallax*. The *geocentric* or *diurnal parallax* uses the radius of the earth. If it is measured when the object is on the horizon and the equatorial radius of the earth is used, it is the *equatorial horizontal parallax.*

The measurement of the parallax of the stars is very difficult. Tycho Brahe tried it, and because he could not do it, he refused to believe in the revolution of the earth about the sun. There were no instruments good enough to make such accurate measurements in his time.

The first stellar parallax was that of the star 61 Cygni, measured by Bessel, in Germany in 1838.

In 1903, Dr. F. Schlesinger, of Yale, began the systematic study of parallax and his catalogue lists over 7500 stars that have been measured.

The parallax of the nearest bright star, α Centauri, is only

756 thousandths of one second of arc. That represents the angle of one-half the diameter of a dime three miles away.

Because of the difficulty of making such minute measurements, the parallax of only the nearer stars can be measured by *the direct* or *trigonometric* method. It is not reliable for stars that are over 300 light-years away. For more distant stars there are indirect ways of computing the parallax.

The *dynamical parallax* is a way of finding the masses of a double or binary star when the masses of the two companions are known.

The *spectroscopic parallax* can be computed by comparing the strength of certain lines in the spectrum, with the spectra of other known stars.

The *secular parallax* is the apparent angular displacement impressed upon a star by the motion of the sun. (*see* also GROUP PARALLAX METHOD, HORIZONTAL PARALLAX, LUNAR PARALLAX, MEAN PARALLAX, SOLAR PARALLAX.)

parallax error

Correction to be applied to a SEXTANT ALTITUDE (q.v.) to compensate for the difference between the altitude as observed at the surface or the center of the earth. It is added to the sextant altitude, and decreases with the altitude, being greatest at the horizon and zero at the zenith.

parallel

Short for PARALLEL OF LATITUDE (q.v.).

parallel of altitude

A SMALL CIRCLE (q.v.) on the celestial sphere the plane of which is parallel to the horizon.

parallel of declination

A SMALL CIRCLE (q.v.) on the celestial sphere the plane of which is parallel to the celestial equator.

parallel of latitude

An imaginary SMALL CIRCLE (q.v.) on the earth parallel to the equator and serving to mark geographical latitudes.

parallel sphere

The CELESTIAL SPHERE (q.v.) as it appears to an observer at a pole, where celestial objects appear to move parallel to the horizon, without rising or setting. At the North Pole, the observer sees the North Star at the zenith, the equator is on the horizon, and the same half of the sky is always above the horizon.

parameter

Arbitrary values or assumptions based upon accepted data.

parent, parent element

In nuclear physics, the radioactive nucleus or atom that disintegrates to form a radioactive product or *daughter*. Also called *precursor*.

parhelion (plural: parhelia)

SUNDOGS (q.v.).

parsec

The distance at which a star would have a parallax of one second of arc. One parsec equals 3.258 light years, or 206,625 astronomical units, or 19,150,000,000,000 miles.

partial eclipse

An ECLIPSE (q.v.) during which only a part of the sun or the moon is obscured. (*see* ECLIPSES OF THE SUN, ECLIPSES OF THE MOON.)

payload

(ASTRONAUTICS) The cargo of a rocket, including instruments and crew or passengers, if any. In STEP-ROCKETS (q.v.), the payload of each individual step except the last one is constituted by all the succeeding steps.

peculiar motion of a star

The same as its motion with respect to the average motion of the entire system of stars of which it is a part.

It is the component of the star's observed apparent proper motion which remains after its parallactic motion is eliminated.

peculiar star

A star that does not fit into any of the recognized spectral classifications (*see* SPECTRAL CLASSES); also called *abnormal star.* (Some authors apply these terms to any star that does not belong to the MAIN SEQUENCE of the RUSSELL DIAGRAM [qq.v.].)

Pegasus [the Flying Horse]

A conspicuous constellation just above Pisces, marked by four bright stars forming the "great square."

It represents the winged horse on which Perseus rode when he rescued Andromeda from the Sea Monster. There are several variants of that story.

The great square is easily found. The two stars on the eastern side of the square point north to Polaris, and south to the vernal equinox. The star Alpheratz, at the northeast corner, is also in the head of Andromeda.

Two of the stars in the square are spectroscopic binaries. The others are not remarkable.

pendulum

A mass so suspended from a fixed point, as to swing freely to and fro under the combined action of gravity and momentum.

Used to regulate clocks and for measuring the force of gravity at different places on the earth.

(*see* COMPENSATION PENDULUM, FOUCAULT PENDULUM.)

penumbra

Partial shadow. In eclipses of the sun or moon it is the part of the shadow where the light is not entirely cut off, and so a partial eclipse is seen.

In sunspots it is the partly dark border surrounding the black center of the spot.

penumbral eclipse

see ECLIPSE.

perfect gas

A gas that obeys BOYLE'S LAW (q.v.).

In the laboratory, a gas that is compressed to a density exceeding one-tenth the density of water ceases to obey this law. But it is believed that in the stars the law holds true, even at densities far exceeding that of water.

perfect radiator

see BLACK BODY.

periastron

The time when, and the point at which, the two components of a binary star are nearest to each other in their orbits. (Cf. APASTRON.)

pericynthion

That point in the orbit of a moon rocket which is closest to the moon.

perigee

The point in the moon's orbit where it is nearest to the earth. Its distance is then 221,463 miles. Its mean, or average distance is 238,857 miles, the closest approach to the earth of any orbiting body.

perihelion

That point of the orbit of a planet or a comet where it is nearest to the sun. The earth is at perihelion about January 1, when it is 3.4%, or about 3,000,000 miles nearer to the sun than about July 1, when it is at APHELION (q.v.).

period

The time required for a full cycle of a regularly recurrent series of events to take place. Specifically, the time required for a revolution of a celestial body around its primary. (*see* PERIOD OF A VARIABLE STAR, SIDEREAL PERIOD, SYNODIC PERIOD.)

period of a variable star

The average interval of time required for the variable to go through one complete cycle of its changes.

Generally reckoned from maximum to maximum for Cepheid and long-period variables, and from minimum to minimum for eclipsing binaries.

period-luminosity relation

It has been discovered that there is a very definite relation between the apparent magnitudes and the periods of Cepheid variable stars. The brighter the star, the longer the period.

This makes it possible, as soon as the period has been observed, to compute the absolute magnitude of the star and to calculate its distance.

The following tabulation gives the approximate numerical values of the relationship:

Period in days	*Luminosity (visual), Sun=1*
0.5	100
1.0	175
5.0	700
10	1300
50	7600

periodic perturbations

Small deviations of a planet or satellite from its computed orbit which run through cycles that generally do not exceed a century. (*see* SECULAR PERTURBATIONS.)

periodic table of elements

A table of the chemical elements arranged according to a system of a regular periodic recurrence of chemical and physical properties.

periodic time

The time required by a body for completing one full revolution in its orbit. Usually referred to simply as PERIOD.

Perioeci

(From the Greek *peri*=around, and *oikus* =house.) People who live on the same parallel of latitude, but on opposite

meridians, so that it is noon in one place when it is midnight in the other.

periphery

The circumference or perimeter of a circle, ellipse or other closed curvilinear figure.

Periscii

(From the Greek *peri*=around and *skia*=shadow.) People who live within a polar circle, whose shadows, during some summer days, will move entirely round, falling toward every point of the compass.

Perseids

One of the most prolific meteor showers, the RADIANT (q.v.) of which lies in the constellation Perseus and moves perceptibly during the shower; it consists of very swift and usually rather faint meteors, as many as 50-70 of which can be observed hourly at the time of the maximum (about August 11).

Perseus [the Hero]

A curving line of stars extends from Cassiopeia, southeastward almost to the Pleiades.

It represents the hero who slew Medusa the Gorgon, and then rescued Andromeda and turned the Sea Monster into stone by showing him the severed head of Medusa.

Nearby under the middle of the curve of stars is Algol, the bright and easily seen variable star, called the "demon." (*see* ALGOL.)

personal equation

A systematic error in observations due to the characteristics of the observer; it is the difference between the true reading and that made by the observer.

perturbation

Deviation of a celestial body from its computed orbit owing to the attraction of another body or other bodies. (*see* PERIODIC PERTURBATIONS, SECULAR PERTURBATIONS.)

phase angle of a planet

The angle at the planet between the directions of the earth and the sun, divided by 180°. It gives the fraction of the hemisphere turned toward the earth that is in darkness.

The phase angle is greatest when the planet is near quadrature.

phases (of the moon)

When the moon is in conjunction, i.e., exactly between the earth and the sun, its dark side is toward us, so that in this phase, called *new moon*, it cannot be seen. Then it gradually appears as a thin, ever widening *crescent*, and when it reaches the eastern QUADRATURE (q.v.), it appears as a half-circle; this is the phase called *first quarter*. It then takes on a GIBBOUS (q.v.) shape, and when it is in OPPOSITION (q.v.), turning its illuminated side toward us, it is in the phase called *full moon*. Then it goes again through the gibbous phase, reaching the phase called *last quarter* (or *third quarter*) then it becomes a gradually thinning crescent and eventually reaches the *new moon* phase once again. (Note that Venus and Mercury show all these phases analogously to the moon; the other planets can show only the full and gibbous phases, but can never appear as crescents.)

Phecda

The traditional name of the star γ Ursae Majoris; one of the stars in the bowl of the Big Dipper.

Phenomenon

Any observable event. It is ordinarily applied to an event that is unusual, or of scientific interest.

Phobos

The larger, inner satellite of Mars. It is 15 miles in diameter, is 5,800 miles from the center of the planet, or 3,693 miles from its surface. It revolves about the planet in 7 hours 39 minutes, which is less than one third of Mars' day. This rapid motion makes it rise in the west and set in the east.

As a source of moonlight it would not amount to much. Its light is about 1/60 of that of our moon. (*see also* SATELLITES OF THE SOLAR SYSTEM.)

Phoenix [the Phoenix]

A southern constellation.

Phosphorus

The name given by the Greeks to the planet Venus when it was seen as a morning star.

photoelectric cell

An electronic cell or "tube," often called the "electric eye." Attached to a telescope it is used for measuring slight changes in the brightness of variable stars, the light curves of eclipsing binaries, the sizes of nebulae and of exterior galaxies.

On the 100-inch telescope it could detect the light of a candle 3000 miles away, if it were not for the atmosphere.

When light falls upon the metal potassium, it releases electrons in proportion to the intensity of the light. These carry an electric current through the cell. The strength of this current is a measure of the intensity of the light.

photoelectric photometer

see PHOTOMETER.

photographic magnitude

The MAGNITUDE (q.v.) of a star or another celestial body as determined with a photographic camera, using ordinary plates that are practically insensitive to radiations of wavelengths greater than ½ micron. Thus the measurements are made essentially on the blue and violet regions of the spectrum and at the beginning of the ultraviolet. To fix the zero of the photographic magnitudes, it was decided to assign the same visual and photographic magnitudes to the hydrogen stars of the spectral type A0 of the sixth magnitude. In practice, the international system of photographic magnitudes follows the *north polar sequence* (*see* SEQUENCE METHOD).

photographic rocket

A rocket designed for photographic studies and/or equipped with photographic cameras for this purpose.

photography in astronomy

A very large part of the study of astronomy is now done by photography.

A camera is attached to a telescope and photographs of the stars are made, sometimes with exposures of many hours. These show stars too faint to be seen by the human eye.

Photographs give permanent records that can be studied at leisure and at any time.

Photographic maps of the entire sky are being made with telescopes of the same size and exposures of equal length, at widely separated observatories.

photometer

An instrument for comparing the intensity of light from any source, such as a star, with that of a known source, often a standard candle at a fixed distance.

Such comparison of stars is now often done by comparing the blackness of their images on a photographic negative.

The most accurate measurements are now made with the PHOTOELECTRIC PHOTOMETER which contains a photoelectric cell and is attached to a telescope.

photometric magnitude

see PHOTOGRAPHIC MAGNITUDE.

photometric radius of the metagalaxy

In radio astronomy, the radius of an imaginary sphere of constant density, in which a uniform distribution of the RADIO SOURCES (q.v.), similar to those in the outlying areas and surroundings of our own galaxy, would give a radio intensity equal to that actually observed.

photometry

The science and art of the measurement of light. (*see* STELLAR PHOTOMETRY.)

photon

The smallest quantity of radiant energy.

It is the energy radiated by one energy change in an atom.

It has a different value for each different frequency. Photons of violet light are about twice as energetic as those of red light, because of the greater frequency of violet (shorter wavelength).

photon rocket

Theoretic method of attaining velocities approaching the speed of light for interstellar flight.

photosphere

The visible surface of the sun.

With either the naked eye, or with a telescope, it appears as sharply defined as the surface of a ball. It looks like a layer of brilliant clouds, but it must be entirely gaseous.

The sun becomes opaque at this level; the gases are strongly ionized, due to the high temperature of nearly 11,000°F.

photovisual magnitude

The MAGNITUDE (q.v.) of a celestial body determined from photographs made by using special orthochromatic plates sensitive to red and yellow, with a special yellow filter that eliminates radiation of wavelengths less than approximately 0.5 micron, so as to obtain a combination where the relative sensitivity to lights of different colors more or less equals that of the human eye. The international system of photovisual magnitudes is graduated up to the seventeenth magnitude based on the north polar sequence (*see* SEQUENCE METHOD).

physical pair

Two stars that are really near to each other and doubtless

in slow orbital motion. Real binaries. (*see* OPTICAL DOUBLE STAR and BINARY STARS.)

Pictor [the Painter]

A southern constellation.

Pied Piper

Unmanned satellite designed for reconnaissance.

pile

A synonym for NUCLEAR REACTOR (q.v.), now generally replaced by the latter term.

Pioneer

The second U.S. Air Force lunar probe rocket, fired from Cape Canaveral, Fla., on October 11th at 8:42 Universal time. Designed to circle the moon, this probe traveled only about a third this distance, reaching a record 80,000 miles before returning to the earth. It was equipped to observe the back of the moon in infrared light, among other experiments. The weight of the instrument package was 83.8 pounds.

pip

A deflection of a trace on an oscilloscope indicating either the transmission of a signal or the return of an echo.

Pisces [the Fishes]

The twelfth constellation in the zodiac.

A long, crooked group of faint stars south and east of the great square of Pegasus. It is depicted as two fishes with their tails tied together by a ribbon.

It represents Venus and Cupid, who were frightened by the giant Typhon, and, to escape him, jumped into the Euphrates River and changed themselves into fishes.

The western fish can be easily seen as a circlet of seven faint stars just under the square. The brightest star is Al Rischa, 3d magnitude, the knot in the ribbon.

Three conjunctions of Jupiter and Saturn, and then a triple conjunction with Mars, occurred here in the year 6 B.C., at the

supposed time of the birth of Jesus, and is thought to be a possible origin of the story of the Star of Bethlehem.

Piscis Austrinus [the Southern Fish]

A southern constellation, also called *Piscis Australis.*

Piscis Volans

see VOLANS.

plages

Large, luminous patches of calcium and hydrogen clouds that appear in the vicinities of sunspots or disturbed areas on the sun. They show up prominently in spectroheliograms taken in the K line of calcium. (Formerly they were called *bright flocculi.*)

Planck's constant (h)

see QUANTUM THEORY.

plane

A smooth, level surface either real or imaginary. The top of a table, or the plane of the earth's orbit. (*see* PROPER PLANE.)

planet

A large, solid, spherical mass of matter that revolves in an elliptical orbit, of which the sun is one of the foci. The nine planets which, with the COMETS, PLANETOIDS and METEORS (q.v.) comprise our solar system are, in the order of their distance from the sun: Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune, Pluto. While it is generally believed that countless more suns in our galaxy must have planets, our present instruments do not possess sufficient resolving power to enable us to see any.

planetarium

A very complicated, multiple projector which by means of many lenses produces on a hemispherical dome a picture of the sky, with all the heavenly bodies that can be seen with the naked eye; together with their motion through days and years.

planetary aberration

The apparent displacement of a planet owing to its motion during the time that it takes for light to travel from it to the earth.

planetary motion, laws of

see KEPLER'S LAWS.

planetary nebula

A round or oval mass of nebulosity (*see* NEBULA), sometimes consisting of concentric rings and usually having a central star which is very hot (25,000-100,000 degrees) and therefore much brighter photographically than visually. Altogether about 130 of these nebulae are known; most of them are too faint to be seen without a telescope; the nearest one is about 900 light-years from us, and most of them are several thousands of light years away. The best known ones are the Ring Nebula in Lyra and the Owl Nebula in Ursa Minor.

planetary orbit

The path in which a planet revolves around the sun. (*see* KEPLER'S LAWS.)

planetary probe

(ASTRONAUTICS) A generic designation for the planned unmanned rockets designed to carry scientific instruments and telemetering equipment to other planets, to send back information required before a manned rocket can safely be sent to the planet being thus explored by remote control.

planetesimal

see PLANETESIMAL HYPOTHESIS.

planetesimal hypothesis

A theory of the origin of the solar system, formulated by Chamberlin and Moulton (in 1901), attributing the formation of the planets to an encounter in the remote past between our sun and a star of comparable size. According to this theory,

that star passed so close to the sun that their mutual attraction caused gaseous material to be ejected from both, which soon coalesced into innumerable small bodies, referred to as *planetesimals*; while most of these escaped from the gravitational field of the sun and traveled into interstellar space, many circled the sun in highly eccentric elliptical paths, all lying almost in the same one plane. After successive collisions, mutual attraction resulted in the formation of planets and satellites by a process of accretion; the collisions served also to reduce gradually the eccentricity of the orbits of the resulting planetary bodies and satellites.

planetoid

A synonym for ASTEROID (q.v.).

planetology

The study of planets and satellites, especially in regard to the interpretation of their surface markings.

plasma jet

(ASTRONAUTICS) Stream of electrons and positive ions raised to high temperature by electrical discharge

Pleiades

A very beautiful open cluster of a few hundred stars in the shoulder of Taurus the Bull. Six of the stars are easily visible and are known as the "Seven Sisters." They cover an area a little larger than the full moon.

Several of the stars are surrounded by nebulous clouds, thought to be dust that shines by reflecting the light of the included star.

In mythology they were the daughters of Atlas who were changed into doves and then into stars.

pleochroic halo

Tiny circular halos found in sheets of mica. Caused by the atomic disintegration of a speck of uranium.

Used in estimating the age of the rock in which they are found, and so the age of the earth.

Plough

The name preferred in England for the BIG DIPPER (q.v.).

Pluto

The planet that was discovered by photography.

Small irregularities in the motions of Uranus and Neptune set astronomers at the Lowell observatory searching for another planet farther beyond.

In January, 1930, Tombaugh found on some photographs in the constellation Gemini, a small body that moved among the stars. Repeated observations and careful computation proved it to be a planet, and it was named Pluto.

Not very much is yet known accurately. The best figures are:

Distance from the sun 3,670 million miles, 39.5 times as far as the earth.

Diameter unknown. Probably greater than Mercury and less than Mars.

Period of revolution 248 years.

Mass .8 that of the earth.

pocket chamber

A pocket-size ionization chamber, used to monitor the radiation exposure of personnel.

Pogson's ratio

The magnitude ratio of 2.512 to 1, adopted in star catalogs as the ratio between the brightness of successive magnitudes, so named for N. Pogson who proposed it in 1856, based on the observation of J. Herschel in 1830 that an average first-magnitude star is 100 times brighter than one of the sixth magnitude.

Pointers

The two stars, *Dubhe* and *Merak*, at the end of the bowl of the Big Dipper. A line drawn between them and extended passes very close to Polaris the North Star. These two stars are 5° apart.

In the southern hemisphere the two stars at the top and bottom of the Southern Cross are used similarly to find the south pole of the sky, but there is no bright south star.

polar axis of a telescope

The supporting axis of a telescope which is fixed in bearings at the top of the pier. It is parallel to the earth's axis and therefore inclined to the horizontal at an angle equal to the latitude of the place.

Around this axis the telescope is turned parallel to the celestial equator and so can follow a star all night as it moves across the sky.

polar distance

The angular distance of a celestial body from the elevated pole, measured along the hour circle of the body, in degrees, minutes and seconds, through 180°. It is the complement of the DECLINATION (q.v.). If the declination of the body is of the same name as the elevated pole, the polar distance is $90° - d$; if the declination is of contrary name, it is $90° + d$.

polar glow

A bright, segmented area which is visible in the northern latitudes in the north at midnight. It has been suggested that it is part of the ZODIACAL LIGHT (q.v.) above the ecliptic.

polar lights

see AURORA.

polar sequence

A list of 96 stars within 2° of the north pole, made at Harvard and Mt. Wilson, and used as standards of brightness.

It includes stars of all magnitudes from the second (Polaris) to the twentieth.

see SEQUENCE METHOD.

Polaris (The Pole Star, The North Star)

A second magnitude star that is now very nearly at the north celestial pole. It is at the end of the handle of the Little

Dipper and the end of the tail of the Little Bear. It is a double star, 2,500 times as bright as our sun, but 465 light-years away. It is not exactly at the north pole; about 1°, or twice the apparent diameter of the moon away. It is slowly approaching the pole and will be nearest (26′ 30″) in about 150 years.

Due to precession, the pole star changes in a cycle of 25,827 years. Thuban, in Draco, held the position about 2,750 B.C. It will be Deneb in Cygnus in 10,000 A.D., Vega in Lyra in 13,000 A.D., and Thuban again about 23,500 A.D. Polaris will be back again about 28,000 A.D.

Polaris

An intermediate range surface-to-surface ballistic missile of the U.S. Navy; a solid-propellant rocket with a range of over 1000 miles, capable of being launched from a submerged submarine, equipped with a nuclear warhead. Said to have an overall length of 45-50 feet and a body diameter of about 8 feet. Its velocity is said to be about Mach 15.

polarization

Changing the direction of light waves by passing them through certain media, so that their vibrations are all in the same plane.

polarized light

Light that has been changed, by reflection from a surface, or refraction through certain crystals or solutions, so that its vibrations are all in the same plane.

Light reflected from the moon and from Mercury is polarized.

Sugar syrup polarizes light refracted through it.

Polaroid

A plastic substance that has the property of polarizing light that passes through it.

It is used for filters for observing the sun.

pole

One of the two points on the celestial sphere that have no daily motion. They are exactly at the zenith for observers at the North and South Poles of the earth The altitude of the pole is always equal to the latitude of the observer. The North Star, Polaris, is now about one degree, twice the apparent diameter of the Moon, from the north celestial pole. There is no bright star near the South Pole. (*see* CELESTIAL POLES, GEOMAGNETIC POLES, MAGNETIC POLE.)

Pole Star

POLARIS (q.v.).

poles of the Earth

see WANDERING OF THE EARTH'S POLES.

poles of the ecliptic

The two points 90° from the ecliptic; they are 23½° from the CELESTIAL POLES (q.v.).

poles of the Galaxy

The two points 90° from the galactic equator (a line drawn through the middle of the Milky Way). They are only 28° from the CELESTIAL EQUATOR (q.v.). In Northern Hemisphere, R.A. 12^h 40^m, dec. + 28°; in Southern Hemisphere, R.A. 0^h 40^m, dec. — 28°.

poles of a planet

The points of the intersection of the axis and the surface of the planet.

Pollux

The traditional name of the star β Geminorum (see STARS —*Plate X*).

polyconic projection

Representation of part of the earth's surface by projecting it to a series of cones tangent at various parallels. Angles are not correctly represented, both meridians and parallels are

curved lines, but contours of various sizes and shapes can be shown with little distortion. This is the most widely used projection for maps, and is seldom used for charts.

Population I and Population II

see STELLAR POPULATIONS.

pores on the sun

The smallest visible sunspots. They are a few hundred miles or so across, and are the most numerous spots seen.

position angle

In general, the angle that the great circle running through two given celestial objects forms with the hour circle passing through one of those objects. In the measurement of DOUBLE STARS (q.v.), the angle between the great circle running through both components and the hour circle running through the PRIMARY (q.v.), measured from the north through the east from 0 to 360 degrees.

positive eyepiece

An EYEPIECE (q.v.) consisting of two plano-convex lenses, the convex sides of which face each other. The RAMSDEN EYEPIECE (q.v.) employs two lenses of identical focal length; in its improved version, known as the KELLNER EYEPIECE (q.v.) the focal lengths of the *field lens* and *eye lens* are different.

positron

One of the particles making up an atom.

It has a positive charge and a mass of 9.035×10^{-28}.

It is a positively charged electron.

potential energy

The energy possessed by a body owing to its position.

pound of thrust

(ASTRONAUTICS) A measured unit of the reaction force generated by the hot expanding gases in rocket and jet engines and imparted as propelling force to the rocket by the ROCKET EXHAUST (q.v.).

power

The work accomplished in a given time, i.e., the rate of the performance of work, calculated according to the formula: power = work divided by time.

power of a telescope

see MAGNIFYING POWER.

powered ascent

(ROCKETRY) The upward journey of a rocket with its motor working.

practical astronomy

That branch of ASTRONOMY (q.v.) which deals with the application of the knowledge and information gained by the observer to practical problems, as e.g., in NAUTICAL ASTRONOMY (q.v.).

Praesepe

An open cluster of about 500 stars, 100 of which are brighter than the sun, in the constellation Cancer, the Crab. It is about 30 light years in diameter and 450 light years distant from the earth.

Two small stars, one on either side of it, were called two asses and the cluster the manger from which they fed. It is also called the Beehive.

Galileo discovered that it was a cluster and not nebula, and said he could count 30 stars.

precession

Slow circling of the earth's axis of rotation about the poles of the ecliptic. As a result the plane of the earth's equator will always be inclined 23½° to the plane of its orbit, although the intersections of the two planes are constantly shifting. The result is that the celestial poles will describe a circle in the heavens 47° in diameter, completing one cycle in 25,800 years. Precession is largely due to the moon's attraction of the earth's equatorial bulge. If the moon were always in the plane of the

equator, or if the earth were absolutely spherical, there would be no precessional effect. When the moon pulls on the surplus matter around the equator, the rotating earth resists tilting by precession at right angles to the pull. The inclination of the axis is constant. Sun and planets also play a minor part in precession.

precession of the equinoxes

Slow westward motion of the equinoxes, at the rate of about 50.2″ per year, due to the precessional motion of the earth's axis about the vertical to the plane of the ecliptic. It makes a complete circle in the heavens in about 25,800 years.

precomputed altitude

The *computed altitude* of a celestial body with the *sextant corrections* applied with the reverse sign. It is determined in advance so that the ALTITUDE DIFFERENCE can be determined by comparison directly with the SEXTANT ALTITUDE (q.v.).

precursor

see PARENT.

preferential motions of stars

The motions of the stars are not all random, as was discovered by J. C. Kapteyn in 1905. This motion, also called *star streaming*, is apparently due to stars moving in such a manner as to maintain the shape of our galaxy. The vertices of the preferential motions are in Orion and in Scutum, both quite close to the central plane of the Milky Way. Stars of different SPECTRAL CLASSES show this effect to varying degrees.

pressure effect

see SPECTRUM ANALYSIS.

pressure in the interior of the earth

Pressures inside the earth can be computed from the density of different kinds of rock.

For a considerable depth below the surface, the pressure

increases at the rate of 6,300 pounds per square inch for each mile of depth.

For greater depths, however, the rate declines, because the weight of a given amount of matter decreases and becomes zero at the center of the earth.

The pressure at the center of the earth is probably about 22,500 tons per square inch.

pressure of light

It is well known that radiation exerts pressure on anything that obstructs it. For large bodies the pressure of light is insignificant. For very small bodies it becomes important.

The pressure of sunlight is about 0.0001 dyne per square centimeter. The pressure on a dust particle 1/100,000 of an inch in diameter equals the sun's gravitational attraction. For smaller bodies, like molecules of gas, it is greater and would drive them away from the sun.

The tails of comets are the best illustration of this pressure. Material moves from the head of the comet to the end of the tail, sometimes millions of miles, in about a week.

prestellar material

The nebulous substance which according to certain cosmogonical theories condensed and aggregated and eventually formed the stars.

primary

(1) A sun with respect to its planets, or a planet with respect to its satellites. (2) The brighter member of a double star system. (3) *see* OBJECTIVE.

prime meridian

The MERIDIAN OF GREENWICH (q.v.).

prime vertical

The vertical circle passing through the zenith at right angles to the meridian, and so cutting the horizon exactly east and west. The planes of the prime vertical, meridian and horizon

are mutually perpendicular. (Also referred to as *prime vertical circle.*)

priming of the tides

The appearance of tides earlier than usual, occurring when the tides caused by the sun come shortly before those caused by the moon. (*see* TIDES.)

primordial atom

The giant atom postulated by Lemaître as the origin of the EXPANDING UNIVERSE (q.v.).

principal focus

The position where a lens or a mirror focuses the light of an object at an immense distance.

Principia

The important book published by Sir Isaac Newton, in 1687, in which he stated his laws of MOTION (q.v.) the cause of the PRECESSION OF THE EQUINOXES, (q.v.) the first proof of the revolution of the earth, the law of GRAVITATION, (q.v.) how to determine the orbit of a body from three observations, and many other facts.

prism

A triangular or wedge-shaped piece of glass used for the formation of a spectrum or for changing direction in an optical train.

prismatic camera

An astronomical photographic camera with a prism placed before its OBJECTIVE (q.v.).

probable error

In making such difficult measurements as the parallax of a distant star, astronomers agree on a probable error in their work and say, for instance, that their result is correct within 10% or some other small percentage.

probe

In high-altitude research, an unmanned balloon or missile

sent aloft for test purposes, empty or carrying scientific instruments, cameras, telemetering equipment, etc. In astronautics, the meaning of the term has been extended to include unmanned rockets sent to the moon or other planets (*see* PLANETARY PROBE), preparatory to voyages of manned rockets.

Procyon

The traditional name of the star α Canis Minoris (*see* STARS –*Plate X*).

Project Farside

The code name of the U.S. Air Force program aimed at eventually sending a rocket to the moon.

Project Muskrat

The code name of the cosmic-ray research program of the U.S. Naval Research Laboratory.

Project Stratoscope

A high-altitude photography program sponsored by the Office of Naval Research. In the first phase of the program, put into operation in 1957, cameras were carried 20 miles aloft in balloons. The planned second phase, referred to as *Strato II*, is to culminate in hoisting a 36-inch telescope by balloon to an altitude where the visible universe can be mapped by cameras without interference by the atmospheric envelope of the earth. Scientists hope that it will soon be followed by the launching of a satellite observatory traveling in an orbit with a perigee of 500 miles and an orbital period of 90 minutes, in which it can continue to revolve for decades.

Project Vanguard

A designation of the official U.S. Navy artificial earth satellite program.

projection

The method or technique of representing an object, an area, or a portion of space on a two-dimensional surface or in a three-dimensional scale model; also the resulting representa-

tion. (*see* AZIMUTHAL EQUIDISTANT PROJECTION, GLOBULAR PROJECTION, GNOMONIC PROJECTION, INVERSE MERCATOR PROJECTION, LAMBERT CONFORMAL PROJECTION, MERCATOR PROJECTION, POLYCONIC PROJECTION, STEREOGRAPHIC PROJECTION, TRANSVERSE MERCATOR PROJECTION.)

prolate spheroid

A solid formed by rotation of an ellipse about its major axis.

prominences on the sun

Sheets of luminous gas standing on edge above the chromosphere, to which they are connected by columns that look like the roots of a tree.

They are scarlet in color and are glowing hydrogen. They are not visible, except at the time of a total eclipse, unless a spectrohelioscope is used.

They often rise to great heights, at enormous velocities, sometimes as much as 500,000 miles in a half hour. Motion pictures show that the gas rises and then streams back into the sun.

They are divided into five classes, in order of their frequency.

1. *Active.* Rapidly moving as if they were being torn apart by a neighboring sunspot.

2. *Eruptive.* These ascend rapidly in a nearly vertical direction.

3. *Spot.* Having the appearance of a fountain.

4. *Tornado.* Whirling like vertical spirals or tightly twisted ropes.

5. *Quiescent.* Showing only minor changes from minute to minute. These sometimes last for several days.

propellant

(ASTRONAUTICS) The fuel that propels a rocket. It may be *solid* or *liquid*. Both types require an oxidizing agent; in solid propellants, the oxidizing agent is mixed with the propellant itself and forms a part of it in a chemical combination; in the

case of a liquid, the oxidizer is carried in a separate tank, and mixed with the fuel proper as the latter enters the combustion chamber. (Occasionally spelled also *propellent.*)

proper motion

The rate of change in a star's direction, or its apparent change of place among the other stars; its motion across the line of sight.

It is measured in degrees of the angle or the arc of the star's change of position in the sky with respect to other stars.

It is usually very small. Only about 50 stars move as much as 2 seconds a year. But Sirius, Betelgeuse, Aldebaran and Arcturus have moved about the apparent diameter of the moon since Ptolemy mapped them 1800 years ago.

proper plane

A plane which is a compromise between a planet's equator and its orbit, with which a satellite's orbit maintains a constant inclination.

protogalaxy

A term used by certain authors to denote a hypothetical giant primordial cloud of gas (Jeans called it a "gas ball") which they assume to have condensed into stars and thus formed the galaxies that we know today. (*see* EXPANDING UNIVERSE.)

proton

One of the positively charged particles conceived as making up the nucleus of an atom.

Its mass is 1.6728×10^{-24} grams.

protoplanet

see PROTOPLANET HYPOTHESIS.

protoplanet hypothesis

The hypothesis of the origin of the solar system proposed by G. P. Kuiper. It is a variation on the NEBULAR HYPOTHESIS

(q.v.) of Laplace, postulating likewise the existence of a "solar nebula" composed like the sun itself chiefly of hydrogen and helium, and containing 5-10% as much material as the sun; according to this theory, as the nebula shrank and flattened, its great mass caused it to become unstable under its own attraction and to break into large clouds of gas, the *proto-planets*, which then cooled, condensed and contracted further and so evolved into the present planets.

Proxima Centauri

The sun's nearest neighbor among the stars.

It is a faint, telescopic star, magnitude 11, a little more than 2° from the bright star Alpha Centauri, in the Centaur. It is not visible in most of the United States.

It is the third member of the triple star Alpha, and as it circles the larger stars it sometimes comes closer to the sun, and the earth, than its brighter primary.

Ptolemaic system

The solar system according to Ptolemy, a Greek who lived at Alexandria about 150 A.D.

He thought the earth was fixed at the center, and the sun and moon revolved about it in circular orbits. The planets revolved on small circles, called epicycles, whose centers revolved about the earth on larger circles called deferents.

pulsating stars

Variable stars, CEPHEIDS (q.v.) and MIRA-TYPE STARS (q.v.) that are believed to expand and contract like a balloon.

The gas pressure inside the star causes it to expand. Its density becomes less and its temperature falls, causing it to appear redder.

Then gravity overcomes the gas pressure and the star contracts, becoming denser, brighter, hotter and whiter.

These alternations repeat in the period of the variability.

More than 1500 such variables are known.

pyranometer

An instrument for measuring the transparency of the sky and so determining the amount of solar radiation.

pyrheliometer

An instrument for measuring the intensity of the sun's radiation.

It contains a thermometer for measuring the rate at which the sun's radiation raises the temperature of a small quantity of water or mercury, or of a metallic disk.

Observations with it are made every day at the Smithsonian Astrophysical Observatory, and records are kept of the variations of the sun's heat.

Pyxis [the Compass]

A part of the old constellation *Argo*, regarded by astronomers as a separate constellation. Also referred to as *Pyxis Nautica* (the *Sailor's Compass*).

Q

quadrant

(1) One quarter of a circle; an angle of 90°.

(2) One of the early instruments for measuring the altitude of celestial bodies, consisting of a graduated arc of 90°. It was replaced by the sextant which is less cumbersome.

Quadrantids

A meteor shower, the RADIANT (q.v.) of which lies north of the constellation Corona Borealis; it consists of very swift meteors, the long trails of which can be seen with maximum intensity about June 2.

quadrature

Two bodies are in quadrature when their difference in celestial longitude is 90°.

This is the position of a superior planet when its elongation is 90°, east or west, depending on the direction of the planet from the sun.

The moon, when in the first or last quarter, is in quadrature with the sun.

quantity effect

see SPECTRAL LINES.

quantum (plural: quanta)

An elemental unit of energy according to the QUANTUM THEORY (q.v.).

Its value is $h\nu$, where h is Planck's constant, 6.55×10^{-27},

and v is the frequency of the vibrations or waves with which the energy is associated.

quantum theory

The theory advanced by Planck, a German physicist, that in the emission or absorption of energy by atoms or molecules, the process is not continuous but takes place by steps, each step being the emission or absorption of an amount of energy, hv, called a QUANTUM (q.v.).

quarter-wave plate

A very thin plate of mica or other doubly refracting crystal.

When plane polarized light falls on such a plate, it emerges as two beams, polarized at right angles. These join into one beam that is circularly polarized, because the thickness of the plate permits one to gain a quarter wave on the other.

Circularly polarized light falling on the plate becomes plane polarized.

quartz-polaroid monochromator

A device developed by the French astronomer Lyot about 1938 to serve as a light-filter that transmits only a selected very narrow range of wavelengths.

quiescent prominence

The least active and longest-lasting of the solar PROMINENCES (q.v.); its most commonly occurring form is called "haystack." (*see also* DARK FILAMENT.)

quintant

An instrument constructed on the same principle as a sextant, but embracing one-fifth of a circle, i.e., 72°.

R

r, r unit

The symbols for ROENTGEN (q.v.).

rad

A unit of radiation, equal to the absorption of 100 ergs of energy per gram. It is a measure of the energy imparted to matter by ionizing particles per unit mass of irradiated substance at the site considered. The purpose of the introduction of this unit was to extend the definition of the ROENTGEN (q.v.) to apply to all types of radiation.

radar

*Ra*dio *D*etection *A*nd *R*anging. Determining distance by measuring the time required by a radio signal to travel to a target and to return, and the direction, by noting the position of the antenna, which transmits a narrow beam. (*see* OSCILLOSCOPE.)

radial motion

When stars are moving either directly toward or away from the earth, they do not change their apparent position in the sky. This is called radial motion, or motion in the line of sight.

It can be measured only by the shift of the lines in the spectrum of the star. (*see* DOPPLER EFFECT.)

radial velocity

The speed or rate at which a celestial body is approaching or receding from the observer; it is the velocity of that body

in the line of sight (hence also called *line of sight velocity*). It is measured with a spectroscope, by observing the shift of the spectral lines of the celestial body relative to those of a source on earth (*see* DOPPLER EFFECT). This velocity is expressed in miles or kilometers per second, and is called *positive* when the shift of the spectral lines is toward the red, indicating that the body is receding, and is labeled *negative* when the shift is toward the violet, indicating an approaching motion. The amount of the displacement of the spectral line is directly proportional to the radial velocity. (see also RADIAL MOTION.)

radian

An arc of a circle which is equal in length to the radius.

A radian measures 57.3° or 3437.7 minutes or 206,264.8 seconds.

It is a constant that is useful in solving certain problems.

radiant energy

All the energy emanating from a body in the form of waves or radiations.

It includes light, heat, infrared and ultraviolet, and probably other electrical forms.

radiant flux

see FLUX OF RADIATION.

radiant of a meteor shower

The center of a small area in the sky from which the trails of the meteors forming a shower appear to be radiating outward. Each meteor shower is named after the constellation in which its radiant is located (e.g., Perseids).

The meteors are actually travelling in parallel paths, and the radiant is the vanishing point in the perspective of their trails. It is really a small area instead of a point

radiation

The process of the emission of energy in the form of waves,

and their propagation through vacuum, space or material media; the energy emitted or so propagated.

radiation counter

A device that responds to the passage of nuclear radiation, by electronic amplification producing an audible click or a count registered through some mechanical recorder.

radiation in the atmosphere

The air has different effects on the radiations which it receives from the sun and the earth, depending on the wavelengths of the radiation.

It stops most of the very short waves of extreme ultraviolet light. This is largely done by the ozone in the upper air, 10 to 40 miles above the surface of the earth. Ultraviolet light is destructive to life.

It scatters the short waves of violet and blue light. This accounts for the blue of the sky, for the brightness that prevents us from seeing the stars in the daytime, and for the red in the sunset.

It transmits the longer waves of yellow, orange and red light to the surface of the earth. A part of this light is reflected, another part is absorbed and serves to heat the surfaces on which it falls, and then is radiated back into the air.

It absorbs the still longer heat waves, which the earth radiates, and is warmed by them. The radiation from the earth consists nearly wholly of waves much longer than the reddest light. Part of this heat is returned to the earth and the objects on it. The rest passes slowly out into space.

The air acts like a great blanket around the earth, protecting it from the rapid loss of its heat.

This effect is like the glass roof of a greenhouse which lets the sun's light and heat enter freely but prevents the escape of most of the heat that they produce. Water vapor is important in producing this effect.

radiation laws

Statements of the relations between the temperature of a body and the quantity or quality, or both, of the radiation that it emits. They apply to a perfect radiator, i.e., a BLACK BODY (q.v.). (*see* STEFAN'S LAW, WIEN'S LAW.)

radiation pressure

The force or mechanical pressure exerted by electromagnetic radiations, including light, on surfaces toward which they are propagated. (*see* PRESSURE OF LIGHT.)

radiative equilibrium

The transfer of energy through a star by radiation, absorption and re-radiation at such a rate that each part is maintained at the appropriate temperature.

radio astronomy

That branch of ASTRONOMY (q.v.) which is concerned with the study of the electromagnetic impulses of radio energy emitted by celestial bodies and regions (*see* RADIO SOURCE, DISCRETE RADIO SOURCES), and the study of the universe by using radio waves instead of visible light frequencies. (*see also* SOLAR RADIO ASTRONOMY.)

radio interferometers

Instruments developed by radio astronomy for the measurement of extremely small distances (e.g., the width of radio sources less than one minute of arc in diameter), to study distributions of brightness over objects of the same order of size. They can be defined also as radiometers or RADIO TELESCOPES (q.v.) that have the special distributions of relative power sensitivity ("directional diagram") that are produced by interference between distinct wave trains and thus can register the result of the interference between separate wave trains. There are numerous varieties and models, which can be classified in two broad classes: *twin-wave interferometers* and *multiple-wave interferometers*.

radio noise

In radio astronomy, this term is used to denote the emission of electrical energy with a spectrum that is essentially a continuous one, in contradistinction to the discrete frequencies of radio signals. (*see* COSMIC RADIO WAVES, RADIO SOURCE.)

radio pulse

An intense burst of electromagnetic energy of split-second duration.

radio source

A source of interstellar or intergalactic emission in the radio wavelengths. Today it is considered certain that at least the majority of the strong radio sources are not stars; they correspond to numerous classes of galactic and extragalactic objects. (*see* DISCRETE RADIO SOURCES.) They can be classified into at least four broad types: (1) Remnants of supernovae, (2) galactic nebulosities of a new type, (3) normal external galaxies, and (4) peculiar external galaxies.

radio spectrometer

An instrument for the measuring of radio wavelengths. It is used in radio astronomy to investigate a specific atomic spectral line as well as for the survey of the continuous radiation over a wide frequency range.

radio spectroscope

A RADIO SPECTROMETER (q.v.) the panoramic receiver of which sweeps a wide band of frequencies every second.

radio star

The formerly current designation of what today is called a *discrete radio source* or simply a RADIO SOURCE (q.v.).

radio storm

In radio astronomy, a prolonged period of disturbed emission, i.e., one that lasts for hours, at times even for days.

radio sun

The sun as it registers on a radio telescope. Since the con-

tinuous emission of short radio waves originates not only from the visible sun itself, but also from a broad region surrounding it, the radio sun has more than twice the diameter of the visible sun.

radio telescope

An apparatus designed to intercept radio waves emitted from that region of the celestial sphere toward which it is aimed, and to measure the radiation received, i.e., to act as a RADIOMETER (q.v.). Its essential parts are: the AERIAL (q.v.), which intercepts the radiation, the *feeder*, which transmits it to the *receiver*, to be amplified and rectified, and the *output meter*, generally a recording milliammeter, for observing and usually recording the rectified output. Strictly speaking, the apparatus is not a "telescope," since it does not present a picture of the surveyed area of the celestial sphere, but merely shows the mean "brightness" of the emission over the field of the aerial. Its resolving power (the smallest angular distance between two point sources of radio waves that it can still distinguish and register as distinct sites) depends on the ratio of the aperture to the wavelength of the radiation. Radio telescopes are often designed in the form of RADIO INTERFEROMETERS (q.v.) consisting fundamentally of two aerials placed a considerable distance apart.

radio time signals

Time signals are broadcast by radio several times a day, from various stations in the United States and in Europe. They give to all ships on the oceans an accurate check on their chronometers, and so accurate longitudes.

Radio bearings, or direction signals are also sent out, for the aid of ships and airplanes.

radio window

see ATMOSPHERIC WINDOWS.

radioactive

Possessing, exhibiting or relating to RADIOACTIVITY (q.v.).

radioactivity

The spontaneous change in the atoms of certain heavy elements (radium, thorium, uranium, and a few others) by which they give off radiation and slowly change into different elements.

Spontaneous or induced nuclear disintegration accompanied by the emission of electromagnetic radiations or corpuscular particles.

radiobiology

That branch of biology which studies and deals with the effects of radiation on living organisms.

radioelement

A radioactive element or a radioactive isotope of a chemical element. (The prefix *radio-* placed before the name of a chemical element is used to designate a radioelement, as e g , radiocarbon).

radioisotope

A radioactive ISOTOPE (q.v.) of a chemical element.

radiometer

An instrument for detecting and usually also measuring electromagnetic radiation. In radio astronomy, called more generally a RADIO TELESCOPE (q.v.).

radiometric magnitude

The MAGNITUDE (q.v.), of a celestial body as determined by the total amount of radiant energy of all the wavelengths that reach the surface of the earth. The total radiation is measured by the rise in temperature shown by an extremely sensitive thermocouple. The zero of this scale corresponds to the VISUAL MAGNITUDE (q.v.) of a star of the spectral class AO. Also known as the halometric magnitude.

radiometric measurement

Measuring the surface temperature of the moon and the planets by means of a thermocouple.

radioresistance

The relative resistance of substances, especially organic tissue and organisms, to the damaging effects of radiation.

radiosensitive

Likely to react to or to be damaged by the action of nuclear radiation.

radiosensitivity

The relative susceptibility of substances, especially of organic tissue and organisms, to the damaging effect of radiation.

radiosonde

An instrument equipped with elements to determine the pressure, temperature, relative humidity, etc. prevailing in the upper atmospheric layers, and with radio units for telemetric transmission of the data. Radiosondes are carried aloft by balloons, rockets, etc.

radium

One of the radioactive elements, and a derivative from uranium by disintegration.

The amount of radium and of lead in rocks is used in estimating their age.

radius vector

A straight line joining a moving body with any point, outside its line of motion, with respect to which its movement is to be plotted.

radome

A general name for radar turrets that enclose antenna assemblies.

ramjet

(ROCKETRY) A compressorless jet-propulsion device that depends for its operation on the air compression accomplished by the forward motion of the unit. In essentials, it is nothing but an open cylinder with an internal fuel spray.

Ramsden eyepiece

A POSITIVE EYEPIECE (q.v.) consisting of two plano-convex lenses of identical focal length, with their convex sides facing each other; the image is formed in front of the FIELD LENS (q.v.). This eyepiece has no correction for chromatic aberration. (*see* KELLNER EYEPIECE.)

range

Two objects that appear in line. The distance of an object.

range, tidal

Total rise or fall of depth between high and low tide. (*see* TIDES.)

Rankine scale

A temperature scale that uses Fahrenheit degrees, but makes the zero degree signify absolute zero. In the scale, water freezes at 491.69 degrees, and boils at 671.69 degrees.

Rascal

A liquid-propellant air-to-surface attack missile of the U.S. Air Force.

rational horizon

Intersection of the celestial sphere and a plane through the center of the earth and perpendicular to the zenith-nadir line.

RATO unit

(ASTRONAUTICS) An abbreviation for *R*ocket *A*ssisted *T*ake-*O*ff, a BOOSTER ROCKET (q.v.).

ray of light

A line that represents the direction in which the light is propagated.

We picture rays of light as radiating in all directions from the source and continuing always in straight lines, as long as they remain in the same homogeneous medium. If they pass from one medium to a denser or rarer one their direction will be changed by reflection, refraction or DISPERSION. (q.v.)

Rayleigh scattering

Lord Rayleigh discovered that the scattering of light was inversely proportional to the fourth power of the wave length. Thus, blue light of 3800 angstroms is scattered 16 times as much as red light of 7600 angstroms.

rays and rills on the moon

Rays. Long, broad, light colored streaks that radiate, like spokes of a wheel, from some of the moon craters, especially Tycho and Copernicus. They cross mountains and plains, sometimes to a distance of several hundred miles. Their greatest length is 1300 miles, and their greatest width 13 miles. They are neither ridges nor depressions, but simply material that reflects more light because it is of a different color. They are seen best at full moon.

Rills. Narrow, crooked valleys or cracks, a mile or two in width and of unknown depth, ranging from a few to several hundred miles in length. They have no apparent relationship to mountains or craters. They may be cracks formed in a cooling and shrinking surface.

RBE

Abbreviation for RELATIVE BIOLOGICAL EFFECTIVENESS (q.v.).

reaction propulsion

Applicating Newton's third law of motion, t[illegible]ic in rocket science. This law states that for every action there is an equal and opposite reaction. Therefore, the rush of hot gases from the rocket motor causes the rocket to move forward. The more energetic the gas, and the more of it there is, the faster the rocket moves.

receiver

In radio telescopy, the device which converts the signals fed into it by the AERIAL (q.v.) to a form suitable to actuate the output meter; this usually involves a strong amplification of the incoming signals.

recession of galaxies

The increase of the distance between galaxies and an increase in their velocity of recession from us with increasing distance; regarded as one of the proofs of the theory of the EXPANDING UNIVERSE (q.v.).

recorder

In *telemetry*, that part of the telemetering system which receives the impulses from the MEASURAND TRANSMITTER through the TELEMETERING LINK (q.v.) and sorts them and displays them visually (hence also called a *display*), records them electronically, or reproduces them electronically.

re-entry

(ASTRONAUTICS) The return of rockets or missiles from outer space into the atmosphere of the earth without being destroyed or damaged by the heat generated by the air friction of its passage.

rectascension

RIGHT ASCENSION (q.v.).

recurrent nova

A NOVA (q.v.) of which at least two outbursts have been recorded. Altogether six recurrent novae are known. Their brightness shows a more moderate increase and a more rapid decrease than that of ordinary novae.

red magnetism

Polarity of the north-seeking end of a compass magnet. It is the magnetism of the south magnetic pole of the earth.

red shift

Shift of spectral lines toward the red end of the spectrum. It indicates motion away from the observer in the lines of sight. (*see* DOPPLER EFFECT; RED SHIFTS, LAW OF.)

Red Spot of Jupiter

The most surprising feature of the planet JUPITER (q.v.) is

the Great Red Spot, that appeared in 1898 and is still visible, although not so conspicuous as in the first few years after its discovery.

It is about 30,000 miles long in a direction parallel to the equator. It does not rotate uniformly with the planet, but drifts about considerably. This freedom of motion shows that it is a floating disturbance in the atmosphere of the planet, but its nature and cause are unknown.

Other smaller and variously colored spots are seen sometimes. They, too, move about irregularly.

Redstone

A medium-range (300-500 miles) liquid-propellant-powered surface-to-surface rocket of the U.S. Army. A Redstone rocket served as the first stage of the Jupiter C which launched the first artificial U.S. earth satellite, *Explorer I.*

reduction to the sun

In the spectroscopic determination (*see* DOPPLER EFFECT) of the radial motion of a star referred to the sun, this term denotes the correction that has to be applied to the observed radial velocity of the star to allow for the motion of the earth with respect to the sun.

reflecting telescope

A TELESCOPE (q.v.) in which a mirror, instead of a lens, serves as the OBJECTIVE (q.v.).

The largest telescopes in the world are reflecting telescopes, utilizing numerous methods of examining the image. The first reflecting telescope was designed by Newton to overcome the difficulties of chromatic and spherical aberration, and is therefore referred to as the NEWTONIAN TELESCOPE (q.v.). Two other main varieties are the CASSEGRAINIAN REFLECTOR and the GREGORIAN TELESCOPE (q.v.).

reflection of light

When a ray of light passes from one medium to another, as from air into water, or glass, part of the light is turned back,

or reflected at the boundary, the remainder goes on through the water, or glass at reduced speed, in the denser medium.

The angle of the reflected ray is always equal to that of the incident ray.

reflector

see REFLECTING TELESCOPE.

refracting telescope

A telescope of the spy-glass type. It consists basically of *objective* or *object glass* (a lens now usually a compound one which bends or refracts the rays of light so that they converge to form an image of the object observed beyond the lens) and an *eyepiece* (a system of lenses that magnifies the image formed), the two systems being held at the necessary distance from each other by a tube or other device.

The largest refractor in the world is the 40-inch one at Yerkes Observatory. Next largest is the Lick Observatory 36-inch. This type can be made no larger because the weight of the glass in the lens causes the lens to change its optical figure as it is moved. A 50-inch lens was made in France about 1900, but it is not now in use.

refraction

The bending of a ray of light or other radiation as it passes from one medium into another medium that has a different refractive index. Light is refracted toward the perpendicular to the boundary between the two media when the ray of light passes from a more rarefied medium into a denser one, and away from the perpendicular when the medium into which it passes is less dense than the one from which it emerges. (If the path of the ray of light passing from one medium to another is at right angles to the boundary, no refraction occurs.) The refraction of light by the earth's atmosphere results in an increase of the apparent altitudes of celestial bodies. Therefore, the SEXTANT CORRECTION (q.v.) is always negative and decreases from a maximum value at

the horizon to zero at the zenith. (*see* ASTRONOMICAL REFRACTION.)

refractive index

see INDEX OF REFRACTION.

refractor

see REFRACTING TELESCOPE.

regression of the nodes

The slow westward motion of the nodes of the moon's orbit, a cycle being completed in about 18.6 years. This effect is caused by solar attraction. It results in changing values of the maximum declination of the moon and also in a periodic revolution of the perigree point. (*see* NODES.)

regular galaxy

A collective term applied to all external GALAXIES (q.v.) that have rotational symmetry, i.e. the elliptical and spiral galaxies.

Regulus

The traditional name of the star α Leonis (*see* STARS—*Plate X.*)

(ASTRONAUTICS) A medium-range turbojet-propelled guided surface-to-surface missile of the U.S. Navy, produced in two models, the subsonic Regulus I, and the supersonic Regulus II, which differ quite considerably in other details too. The *Regulus I* has an overall length of 32 feet, a body diameter of 54 inches, a take-off weight of 14,500 lbs., velocity Mach 0.9. The *Regulus II*, which can carry a nuclear warhead, has an overall length of 57 feet, a body diameter of 72 inches, a take-off weight in the neighborhood of 25,000 lbs., has a thrust of 12,000 lbs., a range of 800-1000 miles, and a velocity of Mach 1.5-2.

relative biological effectiveness (RBE)

In radiology, the relative effectiveness of the same absorbed dose of two ionizing radiations in producing a measurable biological response.

relative motion

The motion of a body with respect to another.

relativity

see THEORY OF RELATIVITY.

The abbreviation for ROENTGEN EQUIVALENT MAN (q.v.).

remote velocity

The velocity of an object taken as a whole relative to the surrounding fluid, as distinguished from the local velocity of any of its parts.

rep

The abbreviation of ROENTGEN EQUIVALENT PHYSICAL (q.v.).

resolving power

(1) In general, the smallest angular distance between two objects that can still be separated and registered as distinct objects by an optical instrument. The resolving power of the normal human eye is 6 minutes of arc. The resolving power of an optical telescope depends on the size of the objective. The greater the diameter of the objective, the smaller the separations that can be resolved. To find the number of seconds of an arc that a telescope can resolve, divide 4.56 seconds by the objective diameter in inches. (2) In *radio astronomy*, the smallest angular distance between two radio point sources that a radio telescope can still separate and register as distinct sites. The resolving power of a radio telescope depends on the ratio of its aperture to the wavelength of the radiation.

resonance

Radiation (light) passing through a gas may cause the atoms of the gas to radiate light of the same wavelength. This is called resonance.

reticle

A set or a number of spider threads or a series of fine lines

ruled on glass placed in the tube of a telescope so as to be in the principal focus of the EYEPIECE (q.v.); when the instrument is adjusted properly, the central line of the series is exactly over the center of the object of observation. (The simplest form of the reticle consists of two mutually perpendicular wires, which intersect each other in the collimation axis of the telescope; when the point of their intersection coincides with the center of the object observed, the telescope is pointed directly at the latter.) The reticle is useful for measuring such small distances as the separation of the components of a double star, or in a MERIDIAN CIRCLE (q.v.) for observing the exact time of the transit of a star across the meridian.

Reticulum [the Net]

A southern constellation.

retrograde motion

Backward, (westward) motion of the planet among the stars, resulting from the fact that we view it from the moving earth. It is the motion which a planet has when its RIGHT ASCENSION (q.v.) is decreasing.

Each year, when the earth passes a superior planet, such as Mars, the planet appears to move backward for a short time. It is the same effect as seen when a fast passenger train passes a slower freight train on a parallel track; the slow train appears to move backward. (*see* DIRECT MOTION.)

retrorocket

(ASTRONAUTICS) A rocket tube that points toward the front (nose) of the rocket vehicle, to provide a backward directed thrust when fired, in order to decelerate the vehicle.

reversal spectrum

A continuous spectrum crossed by dark lines, or one that contains some lines brighter than others. (*see* DARK-LINE SPECTRUM.)

reversing layer

In the sun's atmosphere, just above the photosphere, there is a layer of cooler and thinner gases that produce the dark lines in the spectrum of the sun.

This layer is only about 300 to 600 miles thick.

The cooler gases absorb the light of the same wavelengths that their light would show if they were hot enough to shine. That makes the reversed, absorption or dark-line spectrum.

Other stars have similar reversing layers.

revolution

The motion of a celestial body around another, as that of a planet around the sun, or that of a satellite around a planet. (*see* ROTATION.)

Rhea

A satellite of Saturn. (*see* SATELLITES OF THE SOLAR SYSTEM.)

rhombic aerial

A highly non-selective rhomb-shaped aerial used in radio astronomy for special purposes, such as radio spectroscopy.

rhumb line

A line on the surface of the earth that forms the same angle with all meridians. It spirals toward the poles except when it runs east-west as a parallel or north-south as a meridian. A rhumb line connecting two points on the same side of the equator is everywhere nearer the equator than the great circle joining the two points.

ribbons

Some forms of prominences on the sun appear like ribbons made up of filaments that are often twisted and looped.

The large ribbons may contain more than a thousand million tons of material.

rice grains

Tiny brilliant patches several hundred miles across, that stand out against the darker background on the surface of

the sun. They appear mostly near the center of the disk. They are short lived, changing the pattern in only a few minutes.

rigel

The traditional name of the star β Orionis (*see* STARS—*Plate X*).

right ascension

A celestial coordinate, it is the angular distance measured from the vernal equinox eastward along the celestial equator to the hour circle of a given star or other celestial body. It can be defined also as the arc of the celestial equator or the angle at the celestial pole between the hour circle of the vernal equinox and the hour circle of the body. It is measured in degrees, from 0 to 360, or more commonly in hours, from 0 to 24.

right sphere

The appearance of the celestial sphere to an observer at the equator of the earth.

The celestial poles are on the horizon. All celestial bodies will rise and set vertically. They will be above the horizon for 12 hours and below it for 12 hours every day. The day and the night will be always equal. Every star in the sky will rise and set every day.

rills on the Moon

see RAYS AND RILLS ON THE MOON.

ring around the moon and ring around the sun

see HALOS.

ring micrometer

see MICROMETER.

rings of Saturn

Saturn is encircled by three circular rings lying exactly in the plane of its equator. They are called the outer ring, the bright ring and the crepe ring.

They are invisible to the naked eye; they were seen by Galileo in 1610, and discovered to be a ring by Huyghens in 1655. In 1675, Cassini saw the black line separating the outer ring from the bright ring. This is CASSINI'S DIVISION (q.v.). The crepe ring was discovered by Bond, of Harvard, in 1850.

The diameter of the ring system is 171,000 miles, 2.3 times the diameter of the planet. The outer ring is 10,000 miles wide. Cassini's division is 3,000 miles. The bright ring is 16,000 miles. Another division is 1,000 miles. The crepe ring is 11,500 miles. The edge of the crepe ring is 7,000 miles from the surface of the planet.

The rings are very thin, probably less than 10 miles. They become almost invisible when we see them edgewise every 15 years.

The rings are composed of an immense number of small, solid bodies, like a swarm of meteors or of tiny satellites, each revolving in its own orbit, but so many and so close together that they reflect the sunlight or shining rings. We can think of them as broken rocks, pebbles and dust, the smallest not as fine as flour, with a total mass less than a hundredth that of our moon.

There are two proofs showing that the rings are not solid.

The outer and the crepe rings are transparent. One of the satellites has been seen through the crepe ring. Bright stars can be seen through the outer ring.

The inner part of the rings revolves faster than the outer parts. The inner edge of the bright ring moves 2½ miles a second faster than the outer edge of the outer ring. The reverse would have to be true if the rings were continuous.

The outer edge of the outer ring revolves in 7 hrs. 46 min., which is faster than Saturn rotates (10 hrs. 14 min.); so it would appear to move westward across the sky.

If we were to make a scale model of Saturn, using a tennis ball for the planet, the rings would have to be of the thinnest tissue paper.

Roche's limit

The distance from the center of a planet, 2.44 times its radius, within which a liquid satellite of the same density would be torn into small pieces by the tide-raising forces of the planet.

All parts of Saturn's rings lie within Roche's limit.

rocket

(ASTRONAUTICS) A jet-propelled vehicle, designed for travel in the atmosphere as well as in outer space, and which derives its propelling force (*thrust*) by ejecting the hot, expanding gases generated in its *motor* (*see* ROCKET MOTOR) from the propellant carried by it. Rockets (or strictly speaking, rocket motors) can be divided into two general classes: *solid-propellant* and *liquid propellant rockets*, according as the propellant used is in a solid or liquid form. Another classification divides them into MONOPROPELLANT and BIPROPELLANT ROCKETS (qq.v.). Rockets are variously classified also according to their intended purpose and application (*see, e.g.*, FERRY ROCKET, LANDING ROCKET, ORBITAL ROCKET, PHOTOGRAPHIC ROCKET, etc.). Note that the word *rocket* is frequently used to indicate *rocket motor* or *rocket tube* as well.

Rockets are distinguished from jets in that they carry the oxidizer for the fuel within the vehicle.

rocket engine

see ROCKET MOTOR.

rocket motor

A motor that is essentially a tube in which a propellant (solid or liquid) burns, and which operates on the principle of rocket propulsion, i.e., by the reaction of a jet of gas expelled backward at high velocity, imparting a recoil in the form of a forward *thrust* to the vehicle or missile. Rocket motors can be divided, according to the state of aggregation of the propellant burned into *solid propellant* and *liquid-*

propellant motors; or, according to the treatment of the OXIDIZER (q.v.), into *monopropellant* motors (using fuel combined with the oxygen or oxidizer in a single substance) and *bipropellant* motors (in which the fuel and oxygen or oxidizer are injected separately into the combustion chamber). All solid-propellant rocket motors belong in the monopropellant class although there are also liquid monopropellants in existence.

rocketeer

A slang term for *astronaut*.

rocketry

The science, art and technique of designing, building and operating rockets.

Rockoon

A combination of a huge Skyhook balloon (made of polyethylene plastic) and a Deacon rocket; used for high-altitude cosmic ray studies.

roentgen (r, r unit)

The unit used in radiology to measure the quantity of absorbed radiation as defined by the amount of ionization produced under specified conditions.

roentgen equivalent man (rem)

In radiology, a dose unit that equals the dose in RADS multiplied by the appropriate value of RBE (q.v.) for the radiation concerned.

roentgen equivalent physical (rep)

In radiology, a unit of tissue dosage equal to an energy absorption of 93 ergs per gram.

Roman calendar

see CALENDAR.

rotating cabin

(ASTRONAUTICS) A cabin in a rocket or other space vehicle,

so built and installed that it rotates in order to create an "artificial gravity" by centrifugal force.

rotation

The motion of a celestial body as it turns on its axis. (*see* REVOLUTION.)

rotation of the Galaxy

Our galaxy is rotating in a period of about 225 million years.

The speed of rotation, at the earth's distance from the center (about 30,000 light-years) is 170 miles per second.

RR Lyrae variables

CEPHEID VARIABLES (q.v.), so named after one of the brightest of their kind; they have very short periods, the shortest known one being less than an hour and a half, and the longest known one a mere 29 hours. They are Class *A* blue giants, and belong to stellar POPULATION II (q.v.). They are very useful in astronomical studies and calculations because their distances can be measured from the lengths of their periods and their apparent brightness. They are reliable aids in the measurement of the distances of the globular clusters and other features of the universe hundreds of thousands of light-years from us. They were known formerly as *cluster variables*, *cluster-type variables*, or *cluster-type cepheids*, because they were first discovered in globular star clusters, but now they are recognized to be present in other parts and groups of the galaxy as well.

Runaway Star

BARNARD'S STAR (q.v.).

running fix

Fix determined by two lines of position with a delay, possibly of hours, between them.

Russell diagram

A diagram, first presented by Russell, in which the ABSO-

LUTE MAGNITUDES (q.v.) of stars are plotted as ordinates against their temperatures or SPECTRAL CLASSES (q.v.) as abscissae. The diagram (*see* Plate VI) shows two principal groupings of the stars: a narrow band that extends from the upper left to the lower right, called the *main sequence* and consisting of the dwarf stars (hence referred to also as the *dwarf sequence*), and a compact swarm above it on the right representing the *giant stars*. The diagram is called also *Hertzsprung-Russell diagram*, in honor of the other independent discoverer of this stellar relationship.

Russell mixture

A theoretical composition for the atmosphere of the sun, giving the possible proportion of the various chemical elements.

RV Tauri stars

A group of VARIABLE STARS (q.v.), named for the best known member, RV Tauri. They are very luminous, their spectra often show bright lines, and their light curves alternate between deep and shallow minima, with periods from approximately 19 to 150 days.

S

Sa, Sb, Sc spirals

see NORMAL SPIRAL GALAXY.

Sagitta [the Arrow]

A very small constellation, showing only four faint stars, just above *Aquila.*

It probably represents an arrow shot at the eagle. Some say it is one of Cupid's arrows.

Sagittarius [the Archer]

The ninth constellation of the zodiac.

A fairly bright group containing one 2nd, four 3rd and six 4th magnitude stars, in the Milky Way, east of Scorpius. The most conspicuous part of it is the Milk Dipper.

It represents the centaur Chiron, son of Saturn, aiming an arrow at the scorpion.

Chiron was called the "bull killer," because when Sagittarius rises, the stars of Taurus set.

Near the northern end of the bow is the point of the winter solstice, where the sun is on December 22.

These stars lie in the brightest part of the Milky Way, and beyond them is the center of our galaxy.

There are several bright star clouds, and star clusters, and two "coalsacks," which are dark nebulae.

Sagittarius Star Cloud

The largest and most magnificent of the star clouds of the Milky Way.

It is believed that the center of our galaxy is beyond this great cloud.

The cloud is very large, estimated to begin about 1500 light-years from the sun and to extend to about 6000 light-years.

saros

The eclipse cycle of 6,585.32 days, i.e., 18 years 11⅓ days (approximately equal to the cycle of the regression of the nodes of the Moon's orbit), in the course of which the centers of the Sun and Moon and the line of nodes return approximately to the same relative positions, and a new cycle of eclipses begins, in which the eclipses recur in approximately the same sequence as in the preceding one, although with their zone of visibility shifted 120° westward. The knowledge of the saros enabled the ancient Greeks to predict eclipses. (*see* ECLIPSES.)

satellite

A body that revolves around a planet; a moon. (*see* ARTIFICIAL SATELLITE.)

satellite station

(ASTRONAUTICS) A SPACE STATION (q.v.).

satellite vehicle

(ASTRONAUTICS) A rocket or other vehicle serving as an artificial satellite.

satellites of the solar system

see Plate VII.

saturated line

When increasing the number of absorbing atoms fails to increase the blackness of a spectral line, the line is said to be saturated. (*see* CURVE OF GROWTH.)

Saturn

The second largest and most beautiful of the planets.

Distance from the sun 886 million miles, 9½ times that of the earth.

Diameter 74,100 miles, 9½ times that of earth.

Period of revolution 29½ years.

Period of rotation 10 hrs. 14 min.

Mass 95 times that of the earth.

Density .71 that of water. If there were an ocean big enough to hold it, it would float in water.

Saturn was the most distant planet known before the invention of the telescope. Its least distance from the earth is 745 million miles, nearly twice that of Jupiter.

It shines as a steady yellow star, brighter than first magnitude.

The planet is very strongly flattened at the poles, by nearly 7,000 miles. It shows cloud belts, more regular than those seen on Jupiter, but not so conspicuous because of the greater distance.

The atmosphere is extensive and is mostly of methane (marsh gas, CH_4) with little ammonia.

The temperature is lower than on Jupiter. Highest observed: —243°F. Much of the ammonia would be frozen out.

Saturn has 9 satellites. One, Titan, the sixth out from the planet, is larger than our moon. Two others, the 5th and 8th, are about half that size. The others are smaller but not as small as the tiny ones of Jupiter. The 9th and smallest, revolves in retrograde direction, that is from east to west. It is 8 million miles from the planet.

The system of three rings is entirely unique. They were discovered by Galileo, but his telescope was not good enough to see them as rings. It looked to him like a cup with two handles.

The rings are clouds of little solid bodies, each revolving in its own, circular orbit, but so many and so close together that they reflect the sunlight as shining rings. (For a fuller description *see* RINGS OF SATURN.)

SBa, SBb, SBc spirals

see BARBED SPIRAL.

scale error

An error in the reading of an instrument owing to an imperfection or imperfections in the graduations on its scale. (Cf. INSTRUMENTAL ERROR.)

scattering of light

A beam of light from the sun does not penetrate straight to the earth's surface. It is deflected and scattered by air molecules and dust particles. This loss of light by scattering is not the same for all colors. Blue and violet rays are affected more than red and yellow.

The blue light reappears as the blue of the sky. The red and yellow become most noticeable at sunset.

In measurements of the intensity of sunlight this scattering must be allowed for.

Schmidt camera

Also called *Schmidt telescope*, although it is used only for photography, not for visual observation. It is a reflecting telescope designed to overcome the aberrations of the conventional REFLECTING TELESCOPES (q.v.), by using a spherical principal mirror, with a thin plate of glass in the center of its curvature so designed that its refraction neutralizes the aberration of the mirror. The instrument utilizes a curved photographic film and very fast lenses (f/1 and f/2); it furnishes photographs of good definition of extensive areas of the sky (at least 5° in diameter).

Schwassmann-Wachmann Comet

This comet, discovered in 1927, is one of the most remarkable ones known. It looks like a comet and travels like a planet. Its orbit is very nearly circular and is entirely between the orbits of Jupiter and Saturn. Its period is 16 years. Its brightness varies widely and rapidly; it increased a hundredfold in four days, in March 1934.

scintillation

Rapid variation of light. Same as TWINKLING (q.v.).

Scorpius [the Scorpion]

A large constellation, very conspicuous in the summer evening sky. The stars more nearly outline the figure than in almost any other constellation.

It was the scorpion that killed Orion when he bragged that no living creature could ever hurt him. It was placed, by Jupiter, on the opposite side of the sky from Orion, so that it could never sting him again.

It is the most brilliant of the 12 constellations of the zodiac.

The brightest star, Antares, is a red giant, 290 times the diameter of the sun and 250 light years away.

In ancient times, Scorpius included the stars of Libra, which were called the Claws, and occupied two signs of the zodiac. The sun is in Scorpius in late October and early November.

Scorpius Centaurus Group of Stars

A very large, moving CLUSTER (q.v.) of stars including Antares, Spica, Alpha Centauri, the stars of the Southern Cross and many others in the southern skies.

Many of the stars are very distant. Those of the Southern Cross are 200 light years, and the bright stars in Scorpius are about 400 light years away.

screening

A synonym preferred in electrical engineering, instrumentation, etc. to SHIELDING (q.v.).

Sculptor [the Sculptor]

A southern constellation.

Scutum star cloud

A comparatively small but very bright star cloud in the Milky Way in the southern constellation Scutum.

It is called "the gem of the Milky Way."

It is estimated that the center of the cloud is about 8400 light-years from the sun, and that its diameter is 1000 light-years in one direction and 3000 in another.

sea level

Average level of the ocean; the plane midway between mean high tide and mean low tide. (*see* TIDES.)

"Seas" on the moon

see MARIA ON THE MOON.

seasons

Differences in climate during the year at different latitudes on the earth.

They are caused by the inclination of the earth's axis, and the resulting differences in the direction of the sun's rays.

Mars has the same seasons as the earth except that they are nearly twice as long. Jupiter has practically no seasons.

second

One sixtieth of a MINUTE (q.v.).

second-order galaxy

see GALAXY OF THE SECOND ORDER.

secondary planet

A rarely used synonym for the term, SATELLITE (q.v.).

secular

Associated with a long period of time.

secular acceleration

A non-periodic element of the motion of the moon, the cumulative effect of which causes the moon to be in advance of its theoretical position by approximately 11 seconds of arc a century.

secular parallax

see PARALLAX.

secular perturbations or inequalities

Changes in the orbit of a planet or satellite that operate in one direction in cycles of thousands or tens or hundreds of thousands of years. (*see* PERIODIC PERTURBATIONS.)

secular variable

A designation often applied to stars the brightness of which seems to have increased or diminished slowly in the course of centuries.

seeing

The quality of the steadiness and clarity of the image of a star in a telescope, i.e., chiefly the relative absence of TWINKLING (q.v.).

The seeing is good when the air is clear and still so that the images of stars or planets are sharp and clearly defined.

Bad seeing may occur on a clear night because the air is turbulent. Rising heat waves, or winds cause excessive twinkling of stars and distortion of images of planets. These also cause more interference of the light waves.

selected areas

see KAPTEYN SELECTED AREAS.

selenocentric

Relating to the center of the moon; referring to the moon as a crater.

selenography

The study and description of the surface of the moon.

semidiameter

Half the angle at the observer subtended by the visible disc of a celestial body. It is applied as a correction to sextant altitudes unless the center of the body is observed. If the lower limb is observed, the correction is positive and is added; if the upper limb is observed, the correction is negative and is subtracted. Semidiameter varies with the distance of the body from the earth. These variations are given in government publications.

semidiameter of the earth

Because the earth is not a spher but an oblate spheroid,

its radius from the center to the pole is less than that from the center to the equator.

Therefore its mean, or average, radius is called its semi-diameter.

It is 3958.89 miles, or 6371.23 kilometers.

semiregular variables

VARIABLE STARS of the red giant type having periods ranging from about 40 to 150 days. They have light curves that are less regular and less periodic than those of long-period variable stars, and they are cooler. Their absolute magnitudes are about 0 or —1.

sensible atmosphere

That part of the atmosphere that may be felt, i.e., that offers resistance.

sensible horizon

The intersection of the celestial sphere and a plane tangent to the earth at the observer's position.

separation velocity

The velocity at which a space missile or space vehicle is moving when some part or section is separated from it; specifically, the velocity of an earth satellite at the time of separation from the carrier.

sequence method

In the determination of the PHOTOGRAPHIC and PHOTOVISUAL MAGNITUDES (q.v.) of stars, the practice of selecting a list of stars in a well accessible region, the magnitudes of which form a graduated sequence and have been carefully compared among themselves, and determining the magnitudes of other stars through comparing their photographs with a photograph of the stars in this sequence and by subsequent interpolation into the sequence. In practice, the international system of photographic magnitudes follows the *north polar sequence*, which contains 96 stars, the magnitudes of which

range from the second to the twentieth, situated near the north pole. In the same way, the international system of photovisual magnitudes is graduated up to the seventeenth magnitude, according to the photovisual magnitudes of the stars of the north polar sequence.

Sergeant

An intermediate range (about 150 miles at the maximum) surface-to-surface missile of the U.S. Army. A solid-propellant rocket with about 60,000 lbs. of thrust, believed to have an overall length of less than 30 feet and a body diameter of 3 feet; take-off weight 30,000 lbs.

Serpens [the Serpent]

A constellation associated with OPHIUCHUS (q.v.).

Serpentarius

An alternative name of the constellation OPHIUCHUS (q.v.).

setting

Disappearance of a celestial body below the western horizon, due to the daily rotation of the earth.

Sextans [the Sextant]

One of the constellations.

sextant

(1) One sixth of a circle. 60°.

(2) An instrument having a graduated arc of [illegible]°, two mirrors and a small telescope. Used, mostly at sea, for observing the altitude of the sun, or of a star, so as to compute the local time, or the position of the ship.

sextant altitude

The angular distance of an object above the visible horizon, as measured by a sextant.

sextant corrections

The corrections that have to be applied to every observation of a celestial body in order to obtain the true altitude

from a SEXTANT ALTITUDE; these corrections are those for INDEX ERROR, REFRACTION, HORIZON DIP, SEMIDIAMETER and CORIOLIS EFFECT (q.v.).

sextile aspect

The position of two bodies which are 60° apart. (Of importance in astrology only.)

shadow

The region of space from which the light coming from some source is cut off by an opaque body. The shadow of a celestial body consists of a darker inner part, conical in shape, called UMBRA, surrounded by a region of less complete obscuration, called PENUMBRA (q.v.). The shadows of celestial bodies produce the ECLIPSES (q.v.).

shadow bands

When observing an eclipse of the sun, a few minutes before totality, quivering, ripple-like shadow bands appear on every white surface.

shadow transit

see TRANSIT.

shaped charge

(ASTRONAUTICS) A mass of explosive with a cavity carefully calculated to focus the force of the explosion in the desired direction.

shell star

A designation applied to the hottest main sequence stars the spectra of which show bright emission lines, since they seem to be surrounded by a tenuous shell of gas, presumably ejected by the star owing to its rapid rotation.

shells of electrons

Certain things about atoms can be better explained by supposing that electron orbits are arranged in successive layers or shells, each composed of orbits considerably larger than the

previous one. When one of these shells is complete, the atom shows no tendency to chemical combination.

The atoms of the inert gases have complete shells.

If an atom (like sodium) has one electron outside the complete shells, it has one unit of chemical valence, or combining power. Calcium has two such electrons, so its valence is two, and so on.

shielding

In nuclear physics and engineering, as well as in astronautics, the material interposed between a source of radiation and an irradiated object for protection against the dangers of the radiation; also, the process of so reducing the radiation hazard.

shift of spectral lines

The shift of spectral lines toward the violet end of the spectrum means that the star from which the light comes is moving toward the earth. If the shift is toward the red, it is moving away. (*see* DOPPLER EFFECT.)

If a line, the wavelength of which is 4000 angstroms, is displaced one angstrom toward the violet, the star is approaching us with a velocity of 1/4000 of 186,270 miles a second, or about 46.5 miles a second. (*see* RED SHIFT.)

shooting stars

Small meteors that appear as starlike objects that dart across the sky at night. They are seen only for a moment and usually leave no trails. (*see* METEORS.)

showers of meteors

see METEOR SHOWERS.

S.I.D.

The abbreviation for SUDDEN IONOSPHERIC DISTURBANCE (q.v.).

sidereal

Measured by the apparent moton of the stars. Marked by the return to the same position in respect to the stars.

sidereal clock

The clock used in astronomical observatories; it keeps sidereal time (*see* TIME), and is set to register $0^h\ 0^m\ 0^s$ (midnight) as the vernal equinox crosses the meridian.

sidereal day

The interval between two successive upper transits of the vernal equinox. (It measures one rotation of the earth.)

sidereal hour angle

The arc of the celestial equator or the angle at the celestial pole between the hour circle of the vernal equinox and the hour circle of a body, measuring westward from the vernal equinox through 360°.

sidereal month

Duration of one complete revolution of the moon about the earth, relative to the stars, 27 days, 7 hours, 43 minutes, 11.5 seconds (a little lesss than 27⅓ days). Its length varies as much as 7 hours due to perturbations.

sidereal noon

The moment when the VERNAL EQUINOX (q.v.) is on the horizon.

sidereal period of a planet

The interval between two successive conjunctions of the planet with a star as seen from the sun. It is the true period of the revolution of the planet around the sun.

sidereal time

see TIME.

sidereal year

Period of one complete revolution of the earth around the sun relative to the stars. Because of the precession of the equinoxes, it is about twenty minutes longer than a tropical year. Its length is 365.2564 mean solar days, or 365 days, 6 hours,

9 minutes, 9.5 seconds, and it increases at the rate of .01 second a century.

siderolite

A type of the stony-iron meteorites known as SIDEROLITES (q.v.).

siderite

An all-metal ("iron") METEORITE (q.v.), consisting of about 90-95% metallic iron with an admixture of nickel and minor quantities of cobalt, copper, phosphorus, sulfur, etc; these metals combine in minerals not native to the earth. On the ground of this structure most metallic meteories have been classified as extraterrestrial. Siderites are divided into three classes: *hexahedrites* (characterized by cubic crystallization; further divided into 2 subclasses), *octahedrites* (octahedral crystallization; subdivided into 5 subclasses), and *ataxites* (essentially structureless masses of metal; subdivided into 3 subclasses).

siderolite

An iron-stone METEORITE (q.v.). The alloys of metallic iron and nickel are arranged in a sort of sponge formation, with cavities filled with silicate substances which suggest crystallization out of a liquid mass. They usually contain from 25% to 50% iron, 2% to 4% nickel, large amounts of silicon and magnesium oxides and smaller amounts of sodium, calcium, aluminum, copper, manganese and other familiar elements. Siderolites are divided into two classes: *sidererolites* (predominantly silicate phase, generally achondritic, with nickel-iron phase; further divided into 2 subclasses) and *lithosiderites* (nickel-iron matrix filled with olivine; further divided into 2 subclasses).

sign

One twelfth, 30°, of the zodiac.

The signs are numbered from the vernal equinox eastward.

They are: Aries, Taurus, Gemini, Cancer, Leo, Virgo, Libra, Scorpius, Sagittarius, Capricornus, Aquarius, Pisces.

They are named for the constellations but do not correspond with them now, as they did 2000 years ago. The stars of Pisces are now in the sign Aries.

Sirius

The traditional proper name of α Canis Majoris (also called the Dog Star), the brightest star in the sky. (*see* STARS–*Plate X.*)

Being not far from the equator it is visible from all inhabited parts of the earth.

Its visual magnitude is —1.43, its absolute magnitude +1.3. Distance from the sun 8.6 light-years. Thus it is the nearest naked-eye star visible from the United States.

It is twice the diameter of the sun, but 27 times as bright. It has a very rapid proper motion of 40,000 miles per hour.

It is a blue-white star, with a temperature of about 20,000° F, and a very dense hydrogen atmosphere.

Seven Egyptian temples were oriented toward it.

It is a binary with a very small companion. (*see* COMPANION OF SIRIUS.)

sky

In the daytime, the sky resembles a blue dome which rests on the earth along the circle of the horizon. The only things that can be seen in it are the sun, and occasionally the moon and Venus. We know that the stars are there, but the sky is so bright that we can not see them.

The air scatters the blue component of the light of the sun, which makes the sky look blue. Longer waves of red and yellow are transmitted, which gives the red colors of sunset and sunrise.

At night the blue becomes almost black, the stars show as twinkling points of light, the planets do not twinkle and are usually brighter than the stars, and the moon shines more brightly than by day. (*see* CELESTIAL SPHERE.)

sky-blue

The blue color of the sky, produced by the scattering of the blue component of the sunlight by the air. (*see* SKY.)

sky wave

Radio wave which is reflected back to earth from the ionosphere.

slack water

The brief time between flood and ebb currents when no horizontal motion of water is observed. (*see* TIDES.)

slit of spectroscope

A narrow opening, with sharp, parallel edges, between two metal plates, through which light enters to the collimator of the spectroscope.

The width of the slit can be varied by moving one or both of the metal plates.

small circle

Any circle drawn on a sphere the plane of which does not pass through the center of the sphere.

Snark

A long-range (over 4000 miles) guided, winged surface-to-surface missile of the U.S. Air Force. Turbo-powered, with solid-propellant-powered booster rocket. Overall length 74 feet, body diameter 54 inches (vertically 67 inches), wing span 42 feet; take-off weight 35,000 lbs. (minimum), thrust 11,000 lbs., velocity close to Mach 1. (A Snark missile, the official designation of which is SM-62, delivered a simulated hydrogen warhead on a tiny ocean target in the South Atlantic "with unprecedented accuracy" on October 31, 1957.)

Sol

The sun.

solar

Pertaining to the sun.

solar apex

see APEX OF THE SUN'S WAY.

solar constant

A measure of the rate at which energy is received by a surface exposed at right angles to the sun's radiation just outside the atmosphere, when the earth is at its mean distance from the sun.

The average value is 1.94 calories a minute per square centimeter.

The value of the solar constant in British units is 1.07 British thermal units per square yard per second.

solar day

see DAY.

solar eclipses

see ECLIPSE OF THE SUN.

solar engine

An engine designed to convert the radiant energy of sunlight to work.

solar eyepiece

A SPECIAL EYEPIECE (q v.) used for viewing the sun. It contains a filter that admits just enough light to form a clear image, and prevents injury to the eye of the observer. An optical wedge may also be used.

solar flare

The designation of the very bright spotlike outbursts on the sun, generally observed in the vicinity of large, irregular sunspots. Solar flares are brilliant eruptions of hydrogen gas and last from a few minutes to an hour or more. They often cause radio fading and interfere with telephone and telegraphic communication. (Also referred to as *chromospheric eruption.*)

solar month

One twelfth of a solar year.

solar motions

The sun has two principal motions: (1) *The sun's way.* Its motion relative to the neighboring stars. It moves, at the rate of 12 miles per second, toward a point in the constellation Hercules. (*see* APEX OF THE SUN'S WAY.) (2) *Galactic rotation.* Due to the rotation of the MilkyWay, our Galaxy, the sun and the neighboring stars, are moving at the rate of 170 miles per second, toward a point in the constellation Cepheus.

solar mountains

FACULAE (q.v.) seem to represent regions where the photosphere (shining surface of the sun) rises above the general level. They are the longest-lived of all solar features. They are from [illegible] to 100 miles high.

Of course they are not mountains like mountains on earth, but mountains of gas.

solar noise

In radio astronomy, radio waves emanating from the sun (*see* RADIO SUN). The term, "noise," is used here to denote electrical energy with a spectrum that is essentially a continuous one, in contradistinction to the discrete frequencies of radio signals.

solar nutation

The NUTATION (q.v.) due to the changing declination of the sun. It amounts to 1.2 seconds in a period of one year.

solar parallax

The parallax of the sun: 8.803 seconds which gives as its mean distance from the earth, 92,870,000 miles or 149,450,000 kilometers.

solar phoenix

A picturesque reference to the CARBON CYCLE (q.v.) which supplies the vast amounts of energy radiated by the sun; the origin of this expression is the restoration of the carbon iso-

tope $_6C^{12}$ in the series of thermonuclear reactions reminiscent of the rise of legendary phoenix from its own ashes.

solar prominences

see PROMINENCES ON THE SUN.

solar radio astronomy

That subdivision of radio astronomy which studies the sun and its emission of electromagnetic energy manifesting as solar radio waves and SOLAR NOISE (q.v.).

solar spectrum

First studied by Newton in 1666. Wollaston, in 1802, saw three indefinite shadings in it. In 1814 Fraunhofer counted 750 dark lines and mapped 350 of them.

The spectrum of the sun is now known as a band of rainbow colors crossed by thousands of dark lines.

It really extends far beyond the visible colors in both directions. Beyond the violet lie the ultraviolet x-rays, gamma rays and cosmic rays. Beyond the red are infrared, heat rays, and radio waves.

solar stars

The class G stars, so named because the sun is in this SPECTRAL CLASS (q.v.).

solar system

The sun and its family of 9 planets (Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune, Pluto); with their 31 satellites or moons about 1500 little planets called asteroids, an unknown number of comets, and millions of meteors and meteor swarms.

It is the only known system of its kind, although others may exist around other stars.

solar time

see TIME.

solid-propellant rocket

A ROCKET (q.v.) the motor of which burns a solid propellant, which is always a MONOPROPELLANT (q.v.).

solstice

The times when the sun seems to stand still before appearing to reverse its direction of motion either north or south.

Summer solstice is in the most northern point of the ecliptic, when the sun is in the zenith at the Tropic of Cancer, 23½° north of the equator, on June 22. This is called Midsummer Day.

Winter solstice. The southernmost point of the ecliptic, when the sun is over the Tropic of Capricorn on December 22.

Because of the leap year rule, the dates vary a little.

solstitial colure

The *hour circle* that passes through the SOLSTICES (q.v.).

solstitial points

The points of the ecliptic, 90° from the equinoxes, at which the sun reaches its greatest DECLINATION (q.v.) north or south.

sonic speed

The speed of an object at Mach 1 relative to the surrounding fluid.

south

The opposite of north.

That one of the cardinal points of the compass which lies in the plane of the meridian, and to the right of a person facing due east.

Southern Cross (Crux)

A small constellation of five stars, far in the southern sky. It is really only a part of the constellation Centaurus, and its stars form the hind legs of the horse part of the figure.

It is very famous in the Southern Hemisphere and its stars are on the flags of Australia, New Zealand and Brazil.

It is visible for only a few nights at Miami, Fla. and Brownsville, Texas, but is too far south to be seen from anywhere else in the United States.

Its top and bottom stars are the southern pointers showing the direction to the south pole of the sky.

Southern Lights

see AURORA.

southing

The difference in latitude toward the south from the last preceding point of reckoning. (*see* NORTHING.)

space

The entire universe beyond the atmospheric envelope of the earth; the near-vacuum in which the solar system, stars, nebulae, galaxies exist. (*see* DEEP SPACE, OUTER SPACE.)

space biology

A branch of biology concerned with life as it may come to exist in space.

space cabin

A pressurized and climatized cabin for use in space flight.

space medicine

The new branch of medical science concerned with the prevention and alleviation of adverse effects of various aspects of space travel (zero-gravity, intensified exposure to cosmic radiations, psychological and psycho-neurotic effects, etc.) on human beings. (*see* SPACE-SICKNESS.)

space platform

see SPACE STATION.

space ship

A manned rocket to be used for interplanetary travel.

space-sickness

A general term for the expected physical and psychological effects of ZERO-GRAVITY (q.v.) on human beings.

space station

(ASTRONAUTICS) A manned artificial satellite, designed to serve as a scientific research station, a rocket refueling or guided-missile warfare base.

space suit

(ASTRONAUTICS) A strong, sturdy garment, analogous to a diving suit, to protect astronauts against the lack of heat, pressure and air, as well as against cosmic radiations, in outer space.

space-time continuum

A continuum postulated and defined by the THEORY OF RELATIVITY (q.v.) as a space of four dimensions which specify the space and time coordinates of an "event," i.e., the three ordinary space coordinates plus a time coordinate.

space vehicle

A contrivance that carries something into or through space, either returning to the earth or not.

space velocity

The true velocity of a star with respect to the sun.

The space velocities of stars are generally of the same order as the velocities of the planets in their revolutions around the sun.

Arcturus has the highest space velocity among the bright stars: 84 miles a second.

spark spectrum

The spectrum of a metal obtained when an electric spark passes between it and another metal.

This is hotter than the arc, and shows lines, called enhanced lines, which arise from ionized atoms.

specific gravity

The density of any substance as compared to an equal quantity of water which is taken as a standard.

specific thrust

(ASTRONAUTICS) The THRUST (q.v.) developed for a unit weight of the propellants ejected per second.

spectral

Relating to a SPECTRUM (q.v.) or spectra.

spectral classes of stars

The stars can be classified in an orderly sequence according to their physical and chemical characteristics as revealed by the spectroscope. The Harvard system of spectral classification, based on the Draper Catalogue, listing about 250,000 stars, and now in universal use, groups them into spectral *classes*, based mainly on a progressive increase and diminution in prominence of certain properties, such as color, temperature, presence and intensity or predominance of certain spectral lines, etc. The classes, in descending order of temperature and excitation, are: *W*, *O*, *B*, *A*, *F*, *G*, *K*, *M*, *R*, *N*, *S* (Actually, the classes *R* and *N* are considered to be a side branch bifurcating from the sequence at the class *G*, and class S another bifurcation at *K*.) The six classes, *B*, *A*, *F*, *G*, *K*, and *M* contain 99% of all the known stars (see RUSSELL DIAGRAM). Class *W* consists of the blue-white, extremely hot WOLF-RAYET STARS (q.v.). Class *O* stars are likewise blue-white and very hot. The stars in Class *B* are also blue-white, but less hot, and are referred to as *helium stars* (for the dominant lines in their spectra), and also as *Orion stars* (for their well known examples, γ and ε Orionis). Class *A* contains white stars, known as *hydrogen stars*. Class *F* stars are yellow-white and referred to as *calcium stars*. Class *G* is a classification for yellow stars, and since the sun is one of them, they are called *solar* (or *sun-type*) *stars*. Class *K* stars are orange. Class *M* stars are red, and so are also the so-called *carbon stars* classified in Classes *R* and *N*, the Class *N* stars being the reddest of all the known stars. Class S consists of a very

few extremely faint stars. (Two further classes of the Harvard classification are designated *P* and *Q*; the former is reserved for gaseous nebulae, the latter for novae.) Each class is subdivided into 10 spectral *types*, each designated by a number from 0 to 9 appended to the capital letter denoting the class (although not all these subdivisions are in current use). Generally speaking, an even gradation between successive types was adopted; thus, for instance, the type *B*5 is halfway between *B*0 and *A*0, the type *A*9 is halfway between *A*8 and *F*0, etc. (*see* also *Plate* No. IX.)

spectral lines

Bright and dark lines in stellar spectra caused by the different states of atoms.

Bright or *emission lines* are given by the transition of atoms from a higher to a lower energy level, or by the fall of electrons from larger to smaller orbits in the atoms.

Dark or *absorption lines* are made by the reverse change when, owing to the absorption of energy by the atom, some electrons are raised from smaller to larger orbits. Spectral lines are subject to a great many influences and effects, such as, e.g.:

Quantity effect. The relative intensities of certain spectral lines in a given element (known as ultimate lines) are due to the total amount of radiating material in the source of radiation, and are proportional to this quantity.

Temperature effect. Certain "temperature lines" appear in the spectrum at definite temperature levels, and so indicate the temperature of the source of radiation.

Pressure effect. The lines of gases under high pressure are widened and shifted toward the red. The shift is proportional to the total pressure. (*see* also DOPPLER EFFECT, EINSTEIN SHIFT, MAGNITUDE LINES, RED SHIFT. ZEEMAN EFFECT.)

spectral types of stars

see SPECTRAL CLASSES OF STARS.

spectrobolometer

A combination of the BOLOMETER (q.v.) and the SPECTROSCOPE (q.v.).

It measures the radiation in a very narrow band of wavelengths, cut out of any portion of the spectrum.

This is important in giving the relation between intensity and wavelength in light from the stars.

spectrograph

An instrument for photographing spectra. It is a combination of a SPECTROSCOPE (q.v.) which is a sorting machine, and a photographic camera, which is a recording machine.

A camera simply replaces the eye of the observer at the view telescope of the spectroscope.

spectrography

The photography of spectral lines, and the analytical study of the photographs obtained.

spectroheliocinematograph

A camera for making motion pictures of the prominences and other features of the sun in monochromatic light.

spectroheliogram

A photograph of the sun made with a SPECTROHELIOGRAPH (q.v.).

spectroheliograph

An instrument with which the sun can be photographed by the light of a single spectral line.

The most satisfactory pictures (called *spectroheliograms*) have been made with hydrogen and calcium light.

Spectroheliograms can also be made with light from different levels in the sun's atmosphere. (*see* SPECTROHELIOCINEMATOGRAPH, SPECTROHELIOSCOPE.)

spectrohelioscope

An instrument similar to a SPECTROHELIOGRAPH (q.v.) but

intended for visual observation and study, instead of photography, of the sun and its spots and prominences.

spectrometer

A spectroscope especially adapted to the measurement of wavelengths of light.

spectroscope

An instrument for producing and studying a spectrum.

It consists of a prism of glass or quartz, toward which two small telescopes are directed. Light enters the first telescope through a narrow slit between the sharp edges of two parallel metal plates. It passes through a lens, the collimator, which makes the rays parallel. Then it goes through the prism, where it is refracted and dispersed into a spectrum. The second telescope is only for viewing and studying the spectrum. The prism is used to study faint stars, comets and nebulae.

Sometimes a *grating* is substituted for the prism, resulting in a GRATING SPECTROSCOPE (qq.v.).

The grating is most useful for spectra of bright sources of light such as the sun or an electric arc. (*see* DIRECT VISION SPECTROSCOPE, ECHELON.)

spectroscopic binary stars

BINARY STARS (q.v.) that are so close together, less than one tenth of a second of arc apart that no telescope can separate them, can be proved to be doubles with the spectroscope.

The Doppler effect produces a shift of the spectral lines in one direction, for the star that is approaching us, and in the other one for the star that is receding, and so the lines appear double. Spectroscopic binaries show eclipses only if the plane of their orbit is inclined but slightly to the line of vision.

spectroscopic parallax

see PARALLAX.

spectrum

(1) In general, a visual demonstration or a photographic or other record of the distribution of the intensity of an elec-

tromagnetic radiation as a function of a given characteristic or property. (2) With reference to visible light, the *optical spectrum*, i.e., the band of light of many colors (usually in rainbow colors) produced when light is transmitted through a prism. (*see* ABSORPTION SPECTRUM, BAND SPECTRUM, BRIGHT-LINE SPECTRUM, COMPARISON SPECTRUM, DARK-LINE SPECTRUM, EMISSION SPECTRUM, FLAME SPECTRUM, FLASH SPECTRUM, FURNACE SPECTRUM, KIRCHHOFF'S LAWS OF SPECTRA, REVERSAL SPECTRUM, SOLAR SPECTRUM, SPARK SPECTRUM, SPECTRUM ANALYSIS, SPECTRUM OF TURBULENCE.)

spectrum analysis

The study and interpretation of spectra and SPECTRAL LINES (q.v.), and the investigation and qualitative analysis of substances and bodies through their spectra and spectral lines. (*see* also DOPPLER EFFECT, MAGNITUDE LINES, RED SHIFT.)

spectrum of turbulence

The relation between the average speed of turbulent eddies in the sun's atmosphere and their sizes.

speed

The rate of change in the position of a moving body, expressed as the ratio of the distance covered to the time unit considered.

spheres of Eudoxus

Eudoxus, a Greek, about 400 B.C., proposed that each planet, and the sun and moon, was on one of a series of concentric spheres around the earth, which rotated one inside another, on different axes.

In the original plan there were 27 spheres. Aristotle increased the number to 55.

spherical aberration

Blurring of the image in a telescope owing to the failure of a lens or a mirror to bring rays from its center and edge to a common focus. The rays of light passing through a lens

near the edge are brought to a focus nearer the lens than those passing near the center. The thicker the lens in proportion to its diameter the greater the spherical aberration. This is corrected by a proper choice of the curvature of the lens surfaces. In the case of telescope mirrors, spherical aberration in the reflected rays is corrected by a minute deepening of the central portion of the curve to form a parabola. (*see* ABERRATION OF LIGHT.)

spheroid

The solid produced by rotating an ellipse around one of its axes.

If rotated about its minor axis it forms an *oblate spheroid*, which is the shape of all the planets. Rotation about the major axis produces a *prolate spheroid.*

spheroidal galaxy

A synonym for ELLIPTICAL GALAXY (q.v.)

Spica

The traditional name of the star α Virginis (*see* STARS—*Plate X*).

spicules

The surface of the chromosphere of the sun is not uniform. It consists of myriads of tiny spicules. These are several hundreds of miles in diameter and extend up to heights of 5,000 to 10 000 miles. They are seen to form as a sort of blister on the surface, which swells until it bursts, and a jet spurts upward. These jets, or spicules are very short-lived, averaging from four to five minutes.

They are probably closely related to granules or rice grains.

spiral galaxy

An EXTERNAL GALAXY (q.v.) that has a more or less distinct spiral shape, characterized by two "arms" coiled more or less closely about it. They fall into two general types: NORMAL SPIRALS and BARRED SPIRALS (q.v.).

sporadic meteor

An individual meteor that does not belong to a METEOR STREAM or SWARM (q.v.).

Spoerer's law

A formula announced by Spörer in 1879 to explain the appearance of SUNSPOTS (q.v.) and their movement to lower solar latitudes.

spring equinox

The VERNAL EQUINOX (q.v.).

spring tides

The highest tides during the month, which occur about the time of full and new moons ,when the tidal effects of the moon and sun reinforce each other, and high tides are higher and low tides are lower than average. (*see* TIDES.)

spring velocity

Average of the maximum flood and ebb velocities at the time of spring tides. (*see* TIDES.)

sputnik

A Russian word, meaning "traveling companion," which, being used in the official designation of Russia's artificial earth satellites, *Sputnik Zemlyi* (meaning "traveling companion of the world," that is, "earth satellite") has for all practical purposes become a "naturalized" English word as a colloquial term for earth satellites in general and Russian-launched satellites in particular. Russia launched two artificial earth satellites in 1957 (*see* SPUTNIK I and SPUTNIK II).

Sputnik I

The first artificial satellite of the earth, launched by Soviet Russia on October 4, 1957; it was carried aloft by a three-stage rocket, consisting of a two-stage liquid-propellant long-range ballistic missile, about 100 feet long and estimated to weigh about 100 tons, with a third stage added to it to carry the satellite in a nose cone. The satellite has been announced

to be a sphere 58 centimeters (22.8 inches) in diameter and weighing 83.6 kilograms (184.3 lbs.), and it circled the earth in an orbit with a perigee of 155.25 miles and an apogee of 559.25 miles. It was equipped with four antennae consisting of metal rods 96-116 inches in length which were folded against the wall of the nose cone and opened out on hinges when the satellite was released from the latter. It broadcast its signals on the wavelengths of 15 meters and 7.5 meters (20.005 and 40.002 megacycles, respectively) until October 26, 1957, when, after completing 326 revolutions in its orbit in 22 days, its batteries were depleted and it ceased to transmit. This satellite is catalogued officially as *Satellite 1957 α 2*, and the third stage of the launching rocket, being brighter than the satellite itself, was assigned the designation of *Satellite 1957 α 1* (*see* NOMENCLATURE OF ARTIFICIAL SATELLITES).

Sputnik II

The second artificial earth satellite launched by Soviet Russia on November 2, 1957 It consisted of the entire third stage of the launching rocket orbiting as a whole, having a gross weight of slightly over 1100 lbs., in an orbit similar to that of SPUTNIK I (q.v.), but with an apogee of roughly 1000 miles. The unique distinction of this satellite, officially catalogued as *Satellite 1957 β* (*see* NOMENCLATURE OF ARTIFICIAL SATELLITES), is that it carried a living passenger, a dog, the first living creature to travel in outer space under zero-gravity for any considerable length of time.

stable

In nuclear physics, this adjective means: incapable of spontaneous changes, non-radioactive.

stage

see STEP ROCKET.

stand

A brief period at high or low tide when no change in water level can be observed. (*see* TIDES.)

standard star

In nautical and aviational astronomy, a star the position of which is so precisely known that it may be used as a point of reference and basis of comparison or calculation in determining the positions of other celestial bodies or terrestrial objects.

standard time

The local mean time designated by competent authority as the standard meridian for a specified area; usually the nearest meridian exactly divisible by 15°. However considerable freedom is given to local choice to conform to convenience and expediency.

star

The stars are suns, and our sun is a star very much like the other stars. They are great globes of gas, shining because they are very hot. All of them are so far from us that they appear only as points of light. No telescope in the world can show any star as a disk.

Number of stars. The total number of the stars in the sky bright enough to be seen without a telescope is about 6000. Only half of the sky is above the horizon at one time, and faint stars near the horizon can not be seen because of the dust and haze in the air. So the average eye, on a clear moonless night, can not see more than 2500 stars.

Telescopes greatly increase these numbers. A one-inch telescope can show about 100,000 stars. The 100-inch telescope shows more than a billion. It is possible to photograph stars which can not be seen by an observer. There are probably about one hundred thousand million stars in our galaxy and there are millions of other galaxies beyond ours.

Magnitude of stars. Hipparchus and Ptolemy divided the naked-eye stars into six magnitudes. It was simply a measure of brightness and has nothing to do with size or distance. They selected the 20 brightest stars and called them 1st magni-

tude. About 40 are 2nd, 100 are 3rd and so on to the 6th magnitude which includes the faintest stars we can see without optical aid.

These divisions have been kept, extended and standardized. The difference in brightness for each magnitude is about 2½. That is, a second magnitude star is 2½ times as bright as one of the third magnitude, etc.

Fractional magnitudes are used, written as decimals, and negative magnitudes for some of the brightest stars.

Altair in Aquila and Aldebaran in Taurus are standard first magnitude stars. Polaris and the two Pointers are standard second. Vega in Lyra is 0 magnitude and Sirius is —1.43.

Temperature and color of stars. The surface temperatures of stars vary greatly. Their color gives an indication of how hot they are.

If a piece of iron is heated it becomes "red-hot." If heated more, it grows yellow and then white. If still hotter, it would be blue.

Red stars have a temperature about 5000° F. Our sun, which is a yellow star, is about 11,000° F. White and blue stars like Sirius and Rigel may be 20,000° to 30,000°.

Size of stars. Their sizes vary greatly. Our sun is more than a million times larger than the earth. The smallest star known is only a little larger than the earth. The largest star is several million times larger than the sun.

Distances to the stars. The stars are so far away that, measured in miles, the distances are too big to have any meaning. The nearest star, except our sun, is about 2,700 times farther away, or 26 million million miles.

The astronomer measures in light-years or parsecs. (*see* LIGHT-YEAR, PARSEC; *see* also BINARY STARS, FALLING STARS, FIELD STARS, GIANT STARS, INTERIOR HEAT OF STARS, LUMINOSITY OF STARS, LOCAL SYSTEM OF STARS, MAIN SEQUENCE STARS, NEAREST STARS, PARALLACTIC MOTION OF STARS, PECULIAR MOTION OF A STAR, PREFERENTIAL MOTIONS OF STARS, PULSATION

OF STARS, SHOOTING STARS, SUPER-GIANT STARS, TWINKLING OF STARS, VARIABLE STARS, WHITE DWARF STARS.)

star atlas

see STAR MAP.

star catalog

A list of stars that indicates various characteristics and important data for each star, such as its magnitude, apparent position (expressed as a rule as its right ascension and declination), etc. The earliest known star catalog copies of which are still in existence is the *Almagest*, made by Ptolemy in the 2nd century A.D., listing 1028 stars with their longitudes and latitudes and the constellations in which they can be seen. Other examples of important star catalogs are: The *Bonner Durchmusterung* (abbreviated as *BD* or *DM*), which with its various extensions lists over 450,000 stars; the *Cape Photographic Durchmusterung*, giving positions of about the same number of stars; the *Henry Draper Catalog* of about 250,000 stars.

star chart

see STAR MAP.

star classes and types

see SPECTRAL CLASSES OF STARS.

star clouds

Huge aggregation of stars forming bright, cloud-like portions of the Milky Way.

The brightest are the SAGITTARIUS and the SCUTUM STAR CLOUDS (q.v.).

star cluster

A group of stars, the members of which are closer to each other than the stars around them. The star clusters are classified into two general types: (1) *Galactic clusters*, also called *open clusters*, are groups the individual stars of which can be seen with a telescope, or even with the naked eye, being

loosely assembled and not very heavily concentrated in their central regions. Over 300 open clusters are known. Good examples are the Pleiades, the Hyades, and Coma Berenices, which are readily visible, the Praesepe and the double cluster in Perseus, where a strong telescope alone can separate the individual stars. The number of the stars in each such cluster ranges from thousands down to so very few that it is difficult to recognize them as a cluster. Most of them are in or near the Milky Way. (2) *Globular clusters* are more compact groups, of a slightly flattened spheroidal shape; they contain more stars (of POPULATION II – q.v.), and in general are more distant from us than the open clusters.

The nearest ones are 22,000, the farthest known ones 225,000 light-years from the sun. Of the approximately 100 known globular clusters distributed spherically around the center of the galaxy only four are visible to the naked eye (only two of the four are visible in the northern United States, viz.: the one in Hercules and the one in Sagittarius). (*see* also MOVING CLUSTERS.)

star counts

The study of the size and shape of our galaxy is based on counts of stars in selected areas of the sky. This was first done by Herschel in 1783.

Counting is now done on photographic negatives all made with the same telescope.

star day

The interval between two successive passages of the same star across the meridian.

star density

The average number of stars contained in a specified volume of space chosen as a unit.

star drift

The term introduced by Eddington and now more or less

in general use instead of Kapteyn's term, "star stream," to designate the two groups of stars recognized to be passing through each other, moving in opposite directions (one toward, the other away from the galactic center, each toward a distinct point lying in the Milky Way and called the *vertex* of the respective star drift) at a relative velocity of about 25 miles per second, with the individual stars having movements relative to each other. The two drifts, referred to as *Drift A* and *Drift B*, contain stars of the spectral classes *A* to *M*. (There seems to be some evidence of a third group that is more or less at rest relative to these two drifts; this group is referred to as *Drift O* and seems to consist of all the Class *B* stars, plus other stars of other classes as well.)

star gauging

William Herschel's method of the study of the arrangement of the stars, consisting in counting the stars shown by an 18-inch reflecting telescope with a field diameter of 15 minutes of arc. He called his star counts *gauges*, and made close to 3400 of them.

star globe

A small scale model of the CELESTIAL SPHERE (q.v.): a sphere with the positions of the various stars and constellations marked on its surface.

star group

A number of stars all of which move in the same direction at the same time. (*see* MOVING CLUSTER, STAR CLUSTER.)

star map

A map showing the relative apparent positions of the stars in the sky. Star maps are prepared from STAR CATALOGS (q.v.) and are often combined in series of twelve, one for each month, forming a *star atlas*.

star names

see NOMENCLATURE OF STARS.

star sphere

The CELESTIAL SPHERE (q.v.).

star stream

Kapteyn's original terms for the two groups of stars discovered by him to be passing through each other, moving in opposite directions (toward, respectively away from the galactic center) at a relative velocity of about 25 miles per second. These groups are now more generally referred to as STAR DRIFTS (q.v.).

star-tracking guidance

(ASTRONAUTICS) *see* CELESTIAL NAVIGATION SYSTEM.

static firing

(ASTRONAUTICS) The ground test (*see* STATIC TESTING) of a rocket motor.

static testing

(ASTRONAUTICS) The testing of rockets, missiles, etc. on the ground under simulated flight conditions

static universe

The universe postulated by opponents of the theory of the EXPANDING UNIVERSE (q v) a closed universe of a finite volume.

station error

The difference in the direction of the plumb on e earth, i.e., the difference between the observed astronomical latitude of a place, and the latitude it would have if the earth were a smooth, homogeneous spheroid

The difference is caused by irregularities in the form and density of the earth, due to mountains and oceans, which change slightly the direction of gravity.

This error is very small, seldom more than 30 seconds, and usually much less.

stationary point in a planet's orbit

One of those points in the orbit of a planet where its right

ascension is neither increasing nor decreasing; at these points the planet appears to stop for a short time as it changes from *direct* (eastward) *motion* among the stars, to *retrograde* (westward) *motion*, or vice versa.

stationary waves

A modern theory of tidal action says that the waves of the tides, instead of progressing from one ocean to another around the world, are developed in each ocean area rather independently, somewhat like the waves that would develop in a long trough of water if one end of it were alternately lifted and lowered.

The water would flow back and forth, waves would rise and fall at the ends, but the middle would remain nearly at rest. There would be no progression of the waves.

statute mile

A unit of length, usually referred to simply as *mile*; it equals 5280 feet, i.e., 1609.3 meters (1.6093 kilometers).

steady-state theory of the universe

The view that the major, overall features and properties of the universe remain unchanged in time. A logical conclusion of this theory is that the universe has no beginning and no end, that time is an infinite flow, and that matter is being constantly created, new galaxies and star clusters formed within an expanding universe at a rate that compensates for their mutual recession owing to the expansion. (*see* EVOLUTIONARY THEORY OF THE UNIVERSE.)

Stefan's law

The total energy, in ergs, emitted in one second by one square centimeter of a perfect radiator is directly proportional to the fourth power of its absolute temperature.

$E = aT^4$; a is a constant, 5.72×10^{-5}.

stellar

Relating to or characteristic of a star or stars.

stellar association

see ASSOCIATION OF STARS.

stellar interferometer

An optical INTERFEROMETER (q.v.) attached to a telescope and used for measuring the angular diameters of stars by observing INTERFERENCE FRINGES (q.v.) formed at the focus of the telescope. In its simplest form, it consists of a device that covers the OBJECTIVE (q.v.) of the telescope, except for two small apertures equidistant from the center and on opposite sides of the same diameter, the separation of which can be varied. The incident light is split into two beams, each of which passes through one of these apertures, and a number of parallel interference fringes is produced, as the distance between the two apertures is increased, the fringes change and eventually disappear. The diameter of the star observed can be computed from the distance between the apertures at which the fringes disappear. (For a description of the modern form of the apparatus, *see* BEAM INTERFEROMETER.)

stellar parallax

The angle subtended at a star by the mean radius of the earth's orbit; therefore, a measure of distances. (*see* PARALLAX.)

stellar photometry

The science and technique of measuring the brightness of stars.

stellar populations

The concept of two types of stars, called POPULATION I and POPULATION II, was introduced by W. Baade following the resolution into stars of the two companion galaxies of M31 by means of photographs taken in red light with the 100-inch Mt. Wilson reflector in 1944. *Population I* consists predominantly of blue-white stars, interstellar gas and dust, and loose clusters of stars; this population is richer in metals and is regarded generally as younger than Population II, and shows an irregular distribution. It is found in the arms of the spiral

galaxies, but not in their central regions. *Population II* resembles what is found in those central regions, in ellipsoidal systems and globular clusters. It consists of red giants, dwarfs, and RR Lyrae (or "cluster-type") variables, and is considered to be the older of the two populations. These stars and clusters show an almost spherical distribution in the galaxy and are concentrated within a thin, flat disk toward the galactic center. (According to C. Payne-Gaposchkin, "we may think of Population II as a sort of gigantic globular cluster that encircles and includes the whole [galactic] system with smaller globular clusters embedded in it.") Bright giants and supergiants are common in Population I, whereas Population II contains no star brighter than a normal giant. Population I has a higher proportion of binary stars, but fewer novae and supernovae than Population II.

stellar spectra

see STAR TYPES.

stellar system

see GALAXY.

stellar temperatures

see COLOR OF STARS.

step

(ASTRONAUTICS) *see* STEP ROCKET.

step rocket

(ASTRONAUTICS) A rocket consisting of two or more components, each of which (referred to as a *step* or *stage*) itself is a rocket and serves as a vehicle or moving LAUNCHING PAD (q.v.) for the next step; each step fires when the preceding step reaches BRENNSCHLUSS (q.v.) and travels on at a velocity equal to the combined velocities of the preceding steps.

stereo comparator

An instrument for viewing two photographs of the stars in the same part of the sky, but taken at different times.

It has a frame for holding two plates side by side, and two eyepieces, one for each eye.

When the plates are adjusted so that most of the star images combine stereoscopically, that is, appear as one to both eyes, any star that is on only one plate, or has moved between the exposures, stands out from the rest.

It is used to discover the proper motion of stars, and stars of varying brightness. (*see also* BLINK COMPARATOR.)

stereographic projection

Representation of part of the earth's surface by projecting it from a point on the surface to a plane perpendicular to the diameter through that point. Both meridians and parallels are curved lines. Angles are correctly represented. Used widely for polar navigation with the pole as the point of tangency.

storm burst

Wild's term for the narrow-band BURSTS (q.v.) observed superposed on the steady enhancement (which he named BACKGROUND CONTINUUM) during a solar NOISE STORM (q.v.).

Strato II

see PROJECT STRATOSCOPE.

stratosphere

A layer of the atmosphere of the EARTH (q.v.), extending from the TROPOPAUSE to the IONOSPHERE (q.v.) i.e. from an altitude of about 7 to that of about 60 miles above sea level.

style

The pin or gnomon of a sun dial. With reference to dates: *Old Style*—according to the Julian calendar, *New Style*—according to the Gregorian calendar.

subatomic energy

see NUCLEAR ENERGY.

subdwarf

A star smaller and, at the same temperatures, fainter and

probably less massive than the main-sequence stars of the same spectral class; the subdwarfs are thus an intermediate stellar type between the MAIN SEQUENCE and the DWARF STARS (q.v.).

subgiant

A star moderately larger and, at the same temperatures, less dense and brighter than the main-sequence stars of the same spectral class; the subgiants are thus an intermediate stellar type between the MAIN SEQUENCE STARS and the GIANT STARS (q.v.).

sublunar point

The geographical position of the moon at any moment.

subsolar point

The geographical position of the sun at any moment.

subsonic speed

Any speed that is less than the velocity of sound (about 760 m.p.h. at normal sea-level conditions). In aeronautical engineering, any speed below Mach number = 0.8.

substellar point

The point on the earth's surface vertically beneath any particular star.

The point where the star is exactly at the zenith.

Geometrically it is the point on the earth's surface which lies on a line drawn from the star to the center of the earth.

sudden ionospheric disturbance (S.I.D.)

The radio fadeout that rapidly follows the appearance of great SOLAR FLARES (q.v.). Such flares are commonly found in the vicinity of sunspots (q.v.).

summer solstice

The position on the ecliptic occupied by the sun about June 22 when it reaches its greatest northerly declination.

sun

The star around which the planets of our solar system revolve and which is the source of all light, heat and life on the earth. It is a class G0 star of +4.85 absolute magnitude (about 100 times fainter than an average class *A* star, and 100 times brighter than an average class *M* star). It occupies a position near the central plane of the Milky Way, about two-thirds of the distance from the center to the edge of our galaxy. It is a great ball of intensely hot gas 864,000 miles in diameter. Its volume is 1⅓ million times that of the earth, but its mass is only ⅓ of a million times, so that its density is ¼ the earth's density or 1.41 times the density of water.

The surface temperature is about 11,000°F. and deep in the interior it must rise to many millions of degrees. The density also must increase toward the center.

The PHOTOSPHERE (q.v.) is the visible surface. It is the region of the SUNSPOTS (q.v.), and FACULAE (q.v.). The more nearly transparent gases above it constitute the sun's atmosphere.

The REVERSING LAYER (q.v.) is a thin layer of cooler gas above the photosphere, where the dark lines in the spectrum originate.

The CHROMOSHERE (q.v.), above the reversing layer, is brilliant red due to the great amount of very hot hydrogen gas. From it the scarlet PROMINENCES (q.v.) arise.

The CORONA (q.v.) is the outermost part of the sun's atmosphere.

The sun rotates as a ball of gas and not like the solid earth. The period at the equator is 24.7 days, at latitude 45° it is 28.2 days, at 60° it is 30.9 days and near the poles about 34 days.

The sun has a magnetic field just as the earth has.

The spectrum of the sun shows several thousands of dark lines, and from them we have learned something of its chemical composition. Of the 96 natural chemical elements known

on earth, 65 have been identified in the sun. The others are probably there but have not been found yet. No others have been found. So the sun is made of the same substances as the earth, but all are in the form of gases because of the high temperature.

sundial

Probably the oldest instrument for telling time. It consists of a graduated dial showing the hours, and a post, called the "gnomon," which casts a shadow on the dial.

They were of many sizes and forms, and were used in many countries until after the invention of clocks and watches.

sundial time

see LOCAL APPARENT TIME.

sun dogs and moon dogs

Bright spots sometimes seen at the right and left of sun or moon, usually on a luminous ring. (*see* HALOS.)

sunseeker

(ASTRONAUTICS) A photoelectric device installed in the nose cone of a rocket, which keeps an instrument or a group of instruments aimed always at the sun regardless of the changes in the attitude of the rocket during its flight.

sunspots

Dark spots that appear on the sun. Their number varies in a cycle of 11 years, but is not entirely regular.

They usually show a very dark central portion, called the UMBRA, surrounded by a lighter border of PENUMBRA. They are roughly circular, but may change size and form quite rapidly. They usually occur in groups. Single spots vary in size from the smallest ones that can be seen, a few hundred miles in diameter, to great ones 50,000 miles across.

They are dark only by contrast with the surrounding photo-

sphere. They are actually quite bright as their temperature is about 7,000°F.

Usually a spot lasts only a few days. Sometimes they reappear after a rotation of the sun. The longest duration ever observed was 18 months in 1840-41.

Very large spots can be seen with the naked eye, properly protected by smoked glass or blackened photographic film. Most of them can be seen only with a telescope.

Displays of the aurora, northern lights, occur when large spots cross near the center of the sun, and so are more frequent at times of sunspot maxima. Magnetic storms occur most frequently at the same times.

One present theory is that sunspots are produced by whirling storms, like cyclones, in the outer part of the sun. Hot gases are carried upward in the vortex, to a region where the pressure is much reduced, and they expand and cool, and flow out over the surface of the sun.

Sunspots are centers of magnetic fields. They often occur in pairs, the individuals of which show opposite magnetic polarity.

sun's way

see SOLAR MOTIONS.

sun-type stars

The class *G* stars, so named because the sun is in this SPECTRAL CLASS (q.v.).

supergalaxy

A group of supersystems of galaxies (cf. LOCAL GROUP OF GALAXIES).

supergiant stars

Immensely large and extremely brilliant stars. They vary from 100 to 10,000 times as bright as our sun, and are large enough to contain a good part of the solar system.

They are much more numerous in the external galaxies which

are irregular or spiral. Several thousands are seen in the larger Magellanic Cloud. They are not found in spheroidal galaxies or in globular clusters. Examples: *Betelgeuse* (a variable)—330-460 times the diameter of the sun. *Antares*—330 times the diameter of the sun. *Mira*—460 times the diameter of the sun. *Ras Algethi*—800 times the diameter of the sun.

superior conjunction

The condition existing when a celestial body is directly opposite to the earth on the other side of the sun, so that both the body and the sun, as seen from the earth, have the same celestial longitude.

superior planets

The six planets which are farther from the sun than the earth is. They are Mars, Jupiter, Saturn, Uranus, Neptune, Pluto. The five beyond Mars and the asteroids are also called OUTER PLANETS.

supernova (plural: supernovae)

The designation applied to some exceptionally bright NOVAE (q.v.) observed in the external galaxies and, rarely, in our own. They are of two types, one about 100 million times, the other about 10 million times the luminosity of the sun, with radial velocities of ejected gases about ten times as great as for ordinary novae. Several very bright novae seen in our own galaxy—as the one observed in 1054, Tycho's star in 1572, Kepler's star in 1604—appear to have been supernovae. F. Zwicky has estimated the average frequency of their appearance in a stellar system as about one in 600 years, which is about one ten thousandth of the frequency of ordinary novae in our Milky Way system.

supersonic speed

Any speed exceeding the velocity of sound (about 760 m.p.h. at normal sea-level conditions). In aeronautical engineering, any speed that exceeds Mach number = 1.3

superuniverse

The cosmos, all of creation.

surface gravity

The force of gravity at the surface of the earth or of another body. (*see* GRAVITY.)

surge

An exceptionally violent solar PROMINENCE (q.v.).

survey instrument

The designation of a wide variety of portable instruments, designed for detecting and measuring radiation.

symbiotic objects

P. W. Merrill's term for a group of stars the spectra of which show exceptionally abnormal intensities of emission lines; these stars frequently display characteristics ordinarily associated with spectra of bodies of very low temperatures and features that usually appear in spectra originating at very high temperatures.

symbols

Aries	♈	Sun	☉
Taurus	♉	Moon	☾
Gemini	♊	Mercury	☿
Cancer	♋	Venus	♀
Leo	♌	Earth	⊕
Virgo	♍	Mars	♂
Libra	♎	Minor planet	①
Scorpius	♏	Jupiter	♃
Sagittarius	♐	Saturn	♄
Capricornus	♑	Uranus	♅
Aquarius	♒	Neptune	♆
Pisces	♓	Pluto	♇
Comet	☄	Conjunction	☌
Star	★	Quadrature	□
First Point of Aries	♈	Opposition	☍

New Moon	●	Longitude of ascending node	☊
First Quarter	☽	Longitude of descending node	☋
Full Moon	○		
Third (Last) Quarter	☾		
Right ascension	α	declination	δ

synodic

Pertaining to conjunction; especially to the period between two successive conjunctions of the same bodies, as of the moon or a planet with the sun. (*see* SYNODIC PERIOD, SYNODIC MONTH.)

synodic month

The month based on phases of the moon; the duration of one complete revolution of the moon about the earth, relative to the sun; the interval between successive new moons or full moons 29 days, 12 hours, 44 minutes, 2.8 seconds (a little more than 29½ days). The synodic month is longer than the sidereal month because the moon must overtake the sun, also moving eastward among stars. This month varies as much as 13 hours, because of the eccentricity of the orbits of both earth and moon. It is called also LUNAR MONTH.

systematic errors

Errors that arise from causes that repeat themselves whenever the same observation is made under similar conditions. They can be detected only by making the observation in a different manner or under different conditions. They do not average out in a run of observations. Once they are known, however, they can be taken into account in handling the data.

Examples of systematic errors might be an incorrect zero point on a scale, instrument flexure, and the like.

synodic period of a planet

The interval between two successive conjunctions of the planet with the sun, as seen from the earth.

syzygy

One of the two points in the orbit of a celestial body where it is in opposition to or in conjunction with the sun; specifically the points in the orbit of the moon where the sun, moon and earth are in a straight line, i.e., where the elongation of the moon is either 0 or 180°.

T

tabulated altitude

The altitude of a celestial body as taken directly from a table of computed altitudes, before interpolation. After a correction is applied, it becomes a COMPUTED ALTITUDE (q.v.).

taenite

A nickel-iron alloy, richer in nickel than kamacite, which together with it forms most of the iron meteorites.

tail of a comet

The large, elongated cloud of gas that usually points directly away from the sun, it appears as the comet approaches its PERIHELION (q.v.) and vanishes again gradually as the comet moves away from the sun.

Talos

A ramjet-powered surface-to-air guided missile of the U.S. Navy, equipped with a solid-propellant booster rocket. Overall length 10 feet (15 feet with booster), body diameter 18 inches, take-off weight over 2500 lbs., maximum range 45 miles (slant).

tangent

Touching at a single point. A line touching a curve or a plane touching a curved solid.

tangential motion

The same as cross motion, perpendicular to the line of sight. (*see* TANGENTIAL VELOCITY.)

tangential transfer ellipse

(ASTRONAUTICS) A TRANSFER ELLIPSE (q.v.) which provides the path to effect the transfer from an orbit around a celestial body to an orbit around another body with the minimum consumption of propellant; so named because it is tangent to the orbits of both celestial bodies.

tangential velocity

The velocity of a star with respect to the sun, at right angles to the line of sight. It equals the angular velocity of the star multiplied by its distance, and is expressed in miles or kilometers per second. Also called CROSS MOTION.

Taurids

A meteor shower the RADIANT (q v.) of which lies in the constellation Taurus; these slow-moving, brilliant meteors can be observed in the first week of November.

Taurus [the Bull]

South of Capella and above and west of Orion is the V-shaped figure of 5 stars marking the face of the Bull.

It represents the animal into which Jupiter changed himself when he carried the princess Europa across the Mediterranean Sea and so gave her name to the continent of Europe.

In the eye of the bull is the red star Aldebaran, the 13th brightest star in the sky. Its diameter is about 5 times that of the sun, and it gives about 90 times as much light. It is 57 light-years away.

The V is the brightest part of the open cluster of the HYADES (q.v.) and of the TAURUS CLUSTER (q.v.).

In the shoulder of the bull is the beautiful open cluster called the Seven Sisters or PLEIADES (q.v.).

Taurus Cluster

A spheroid cluster of about 140 stars in the region of Taurus. It includes the Hyades, but not the Pleiades nor Aldebaran. The cluster is about 58 light-years in diameter and its center is about 130 light-years from the sun.

These stars are all moving toward a point a little east of Betelgeuse in Orion.

tektites

A collective term for small glass objects found in various parts of the earth and generally assumed to have fallen from interplanetary space. Tektites found in Australia are known as *australites*, those found in Texas are called *bediasites*, the ones in Czechoslovakia are referred to as *moldavites*, those in the Philippines are the *rizalites*, etc. The shape of tektites varies from totally irregular to amazingly symmetrical formations; their weight ranges from fractions of an ounce to nearly a pound. Their color varies from black to dark green. They have a high silica content with major admixtures of oxides of aluminum, iron, magnesium, calcium, also sodium and potassium. Some scientists have advocated the theory that tektites are the fragments of a "lost," shattered planet of the solar system; H. C. Urey, however, has suggested that they may be by-products of a direct collision of the earth with the nucleus of a comet, pointing out that their geographical distribution seems to contradict the view that they are fragments of one single mass of glassy material striking the earth.

telemetering link

In TELEMETRY, the means by which the MEASURAND TRANSMITTER transmits the received electrical impulses to the RECORDER (q.v.); it usually consists of a radio receiver and transmitter, but light beams or cables may be used as well.

telemetering pickup

In TELEMETRY, an apparatus that converts instrument readings or mechanical actions into electrical impulses which it feeds into the MEASURAND TRANSMITTER (q.v.).

telemetering system

A system for the measuring, transmission and reception, recording or integration of instrument readings or data by electronic means. Such system is composed basically of TELE-

METERING PICKUPS, a MEASURAND TRANSMITTER, the TELEMETERING LINK, and finally the RECORDER or DISPLAY (q.v.).

telemetry

The technique of transmitting or reading instrument recordings from a distance.

telescope

An optical instrument designed and used to make distant objects appear to be nearer and larger, by the use of lenses or mirrors designed and arranged to bring the light to a focus and produce an image that is then magnified for observation. The instrument consists basically of a large lens or curved mirror to gather light and form the image, and a microscope to enlarge the image formed.

It was invented, probably, by Lippershey, a spectacle maker in Holland in 1608, but first used in astronomy by Galileo in 1609. (*see* GALILEAN TELESCOPE.)

There are several kinds of telescopes:

Refracting telescopes. A large lens at the end of a solid tube is used to gather the light. A series of small lenses, the eyepiece, at the other end of the tube, magnifies the images. The observer looks directly through the tube.

Reflecting telescope. A large concave mirror at the bottom of the tube, which is usually only a framework, gathers the light, reflects it to a smaller mirror which again reflects it to the eyepiece where it is magnified.

Reflectors may have either, or both, of two different styles of mounting.

Newtonian mounting. A small, plane mirror set at an angle of 45°, or sometimes a prism, is placed in the center of the tube, a little inside the focus of the large mirror. This reflects the image out at the side of the tube, where the eyepiece is placed.

Cassegrain mounting. The large mirror has a hole in its center. A small mirror in the center of the tube catches the image and sends it back through this hole to the eyepiece.

The observer looks through the telescope toward the star, as in a refractor.

ASTRONOMICAL TELESCOPES (q.v.) give an inverted image. Those for use on terrestrial objects, and binoculars, have another set of lenses or prisms to give an erect image. This reduces the brightness of the image, and is not necessary when looking at a star or a planet.

It is possible to build mirrors much larger than lenses, so the largest telescopes are reflectors. (*see* TOWER TELESCOPE.)

telescopic comet

A COMET of which only the COMA can be seen, appearing as a faint, nebulous haze in the sky, without any visible NUCLEUS or TAIL (q.v.).

Telescopium [the Telescope]

A southern constellation.

telluric lines

Lines and bands in the sun's spectrum produced by absorption of sunlight in the earth's atmosphere.

Some are caused by oxygen and by water vapor. Great gaps in the infra red are due to water and carbon dioxide in the air.

Telluric lines are distinguished from solar lines by their greater strength when the sun is near the horizon and so shining through a greater thickness of atmosphere.

temperate zones

The two belts around the earth between 23½° and 66½° either north or south latitude, so named because of their temperate or moderate climate.

Here the sun can never be directly overhead, neither can it be circumpolar.

temperature

The degree of hotness or coldness of a body or region, as measured relative to an arbitrary zero point (the zero of the

Fahrenheit or Centigrade scales) or relative to ABSOLUTE ZERO (q.v.).

temperature inversion

The increase of temperature with altitude, produced by certain atmospheric and meteorological conditions.

temporary stars

see NOVA.

terminator

The line between the bright and dark sides of the moon or a planet; it is the sunrise line before full moon, and the sunset line thereafter.

It is a straight line at the quarter moon phase, an ellipse at other phases.

It coincides with the limb of the moon at full moon.

The sharpness of the line of the terminator is one of the indications that the moon has no atmosphere.

Terra

The earth.

terrestrial horizon

The irregular line where the earth and the sky seem to meet. Also called *visible horizon.*

terrestrial longitude

GEOGRAPHIC LONGITUDE (q.v.).

terrestrial magnetism

The earth acts as a great magnet, having two magnetic poles of opposite polarity. These magnetic poles do not coincide in position with the geographical poles (the north magnetic pole is located approximately at lat. 71° N. and long. 96° W., the south magnetic pole is approximately at lat. 73° S. and long. 156° E.).

terrestrial planets

This designation, meaning "earth-type planets," is usually applied to the four planets, Mercury, Venus, Earth and Mars,

which are very much alike. They are of roughly the same size, all fairly dense, as though they were made of stone or iron.

Probably Pluto is greatly like the Earth or Venus.

terrestrial triangle

Navigational triangle when measurements are made on the earth. The vertices of the terrestrial triangle are the position of the observer, the nearest pole and the geographical position of a celestial body. The sides are the co-latitude of the observer, the great circle between the observer and the geographical position and the co-latitude of the geographical position. In this triangle the point of departure may be used for the position of the observer and the destination may be used for geographical position of the celestial body.

Terrier

A short-range (20 miles maximum) shipboard-based solid-propellant-powered antiaircraft missile of the U.S Navy; it is launched by a solid-propellant booster. It is a beam-riding missile; overall length (including booster) almost 27 feet, body diameter less than 1 foot, take-off weight (including booster, 3350 pounds).

Tethys

A satellite of Saturn. (*see* SATELLITES OF THE SOLAR SYSTEM.)

theodolite

see ALTAZIMUTH.

theory

A general principle offered to explain phenomena, and rendered more or less plausible by evidence in the facts or by exactness of the reasoning.

theory of relativity

It has been known since Newton that the relative motions of bodies within a system, like the solar system, are the same whether the system as a whole is at rest or in uniform motion.

Einstein, in 1905, said that all physical phenomena, including light and electricity, are relative and not affected by any uniform motion of the whole system.

For instance, the velocity of light is always the same no matter in what direction the observer is moving with respect to the light. It was proved by experiments that the velocity of light was the same, whether the light was sent in the direction in which the earth was revolving, or at right angles to it.

Einstein's theory said two things that were very different from Newton's ideas. (1) The mass of a body in motion is greater than its mass at rest. Therefore mass, like velocity, is a relative quantity. In acquiring kinetic energy, from its motion, a body gains mass. (2) Time is also relative. Time therefore is a fourth dimension and must be considered in order to understand the workings of things in the universe.

Tests of the theory: Three astronomical tests have received a great deal of attention. They appear to support the theory of relativity

1. The advance of Mercury's perihelion. The major axis of Mercury's orbit rotates faster than it should according to the laws of gravitation. Einstein's theory says it just should behave like that.

2. The displacement of the lines in star spectra. Lines are displaced toward the red by an amount that is directly proportional to the mass, and inversely to the radius of the body. Such shiftings of the lines have been observed for some stars.

3. The apparent displacement of stars seen near the sun. This has been observed in total eclipses of the sun since 1919, when the first test was made.

The curvature of space existing in the vicinity of a massive body, like the sun, affects the course of a ray of light, as well as that of a material body. A ray of starlight which passes near the sun, describes a hyperbolic orbit.

thermal barrier

(ASTRONAUTICS) In atmospheric flights, that speed range

where the heat produced by the friction of the flying object against the air makes that object ineffective.

thermocouple

An instrument for measuring the heat from a star.

It consists of two wires of different metals welded together and connected to a very sensitive galvanometer.

When the heat from a star, in the field of a telescope, falls on the joint of the wires, an electric current is generated that can be measured by the galvanometer.

From the amount of heat received, the temperature of the star can be calculated.

thermonuclear reaction

A NUCLEAR REACTION (q.v.) in which the necessary energy is provided by the collision of particles in a state of thermal agitation which endows them with kinetic energy. The energy of the sun and most stars is believed to be the product of such reactions (*see* CARBON CYCLE).

thermopile

An electrical thermometer of great delicacy, used for measuring radiation.

thermosphere

The IONOSPHERE considered as a region of temperature variation from —28°F. to several thousand degrees.

third quarter

see LAST QUARTER, PHASES.

Thor

A surface-to-surface intermediate range (1500 miles) guided missile of the U.S. Air Force. It is a liquid-propellant rocket with 135,000 lbs. of thrust and a velocity said to reach Mach 15.

thrust

(ASTRONAUTICS) The propelling force imparted to a rocket, as a recoil, by the hot gases ejected in the rocket exhaust.

Technically, the thrust developed by a rocket motor is, under ideal conditions, the product of the mass flow and exhaust velocity. (*see* POUND OF THRUST, SPECIFIC THRUST.)

tidal current

Horizontal motion of the water due to tidal action. (*see* TIDES.)

tidal friction

The daily movement of many millions of tons of water causes friction along the shores and on the bottoms of shallow seas. The energy so lost is dissipated as heat, but the friction tends to slow the turning of the earth. This slowing is very slight. It is calculated that it lengthens the year by one second in one hundred thousand years.

The tides have also a very slight effect on the motion of the moon. The attraction of the tidal bulge increases the speed of revolution of the moon, and so the moon moves farther from the earth in a very slowly expanding spiral. It can be computed that the distance of the moon increases about five feet in a century due to this action of the tides.

tidal hypothesis

see TIDAL THEORY OF THE EARTH-MOON SYSTEM, TIDAL THEORY OF THE SOLAR SYSTEM.

tidal range

see RANGE, TIDAL.

tidal stand

see STAND.

tidal theory of the earth-moon system

Theory says that under the action of the tides both the month and the day are slowly increasing in length. If this continues into the far distant future, there will come a time when they will both be equal to about 55 of our days

The moon will then be much farther away than it is now,

and the earth will turn one side always toward the moon, as the moon does now to the earth.

Then the effect of the sun tides will reverse the process, and the moon will draw closer to the earth again.

Any effect of this motion will require many billions of years. It may result in the ultimate disintegration of the moon. (*see* ROCHE'S LIMIT.)

tidal theory of the solar system

A recent theory of the creation of the solar system, formulated by Jeans and Jeffreys. It resembles the PLANETESIMAL HYPOTHESIS (q.v.), in that it states that the tides raised in our sun by the close approach of another star (the version proposed by Jeffreys even postulates an actual collision and is hence called the *collision hypothesis*) became so high that huge quantities of gas broke loose from the sun and streamed away in opposite directions, some toward the other star, others away from it; much of this material fell back into the sun, but a considerable portion of it solidified and collected to form the planets and their satellites. The *planetesimal hypothesis* and this *tidal theory* are often referred to as *hypotheses of dynamic encounter*.

tides

The alternate rising and falling of the surface of the ocean, and of waters connected with it. They are caused by the gravitational attraction of the sun and the moon.

Because the moon is much nearer the earth than the sun is, its attraction is greater, and because the water is free to move, it is pulled toward the moon, and rises as a bulge on the side of the earth that is under the moon. On the opposite side of the earth, the moon's gravitation pulls the earth away from the water and leaves the water as a slightly smaller bulge. So there are two high tides and two low tides on the earth all the time. Because of the rotation of the earth, these tidal bulges and hollows move westward around the earth everyday. The exact time is 24 hrs. 50 min. due to the eastward

motion of the moon in its orbit. The time between high tide and the next high tide is therefore 12 hrs. 25 min.

The average tidal range in the center of the ocean is between 2 and 3 feet. As the tidal bulge comes near the shores, friction on the bottom and the shape of the shore line, make it vary greatly. In many places it is 6 to 8 feet, and in the Bay of Fundy, tides of 50 feet are not uncommon and they have been recorded to reach over 70 feet.

There is a sun tide as well as a moon tide. Because the sun is so much farther from the earth, its tide-raising power is less than half that of the moon.

Spring tides. Twice every month, at new and full moon, the sun, earth and moon are in a straight line. Their pulls are therefore in the same direction and the sun tide is added to the moon tide. This causes unusually high high tides and low low tides. Spring tides have no connection with spring as a season.

Because the moon's orbit is an ellipse and not a circle, its distance from the earth varies. The spring tides that occur when the moon is at perigee are the highest tides of all.

Neap tides. At the time of the first and last quarters of the moon, the sun and moon being at right angles with respect to the earth, the sun tide is subtracted from the moon tide. This causes unusually low high tides and high low tides. These are called neap tides.

Earth tides. The pull of the moon causes tides in the solid body of the earth as well as in the water. They are too small to be noticeable except by very careful measurements, but they do amount to between 8 and 10 inches.

Similarly there are tides in the air that can be measured as slightly increased air pressure when the moon is overhead. (*see* DIRECT TIDES, OPPOSITE TIDES.)

tides in lakes

These tides are very small. At Chicago, the tide in Lake Michigan has a range of about 1¾ inches. The tides of the

Mediterranean are of the lake tide type, averaging about 1 foot.

time

The interval or period of duration between two given events, measured by the apparent movement of celestial bodies around the earth. The rotation of the earth is the master clock by which all terrestrial and celestial happenings are timed. The *day* is a natural fundamental unit of time. Longer periods, as the week and calendar month, and shorter divisions as the hour, minute and second, are arbitrary, man-made conveniences.

Various devices have been invented for measuring and recording time. (*see* SUNDIAL, WATER CLOCK, CLOCKS, CHRONOMETER, etc.)

Sidereal time is based on the stars. Sidereal noon is when the vernal equinox crosses the meridian. It is reckoned through 24 hours to the next noon. It is used by astronomers in the observatory because since it is star-time, the stars rise or transit always at the same sidereal time. It will agree with standard time about Sept. 21. After that it gains nearly four minutes a day, which totals one whole day in a year. Sidereal time is not convenient for ordinary purposes.

Apparent solar time is the time shown by a sundial. The day begins at midnight, and noon is when the sun crosses the meridian of the observer's place on earth.

The sun is not a good time-keeper. It runs fast or slow, at times nearly a half minute a day, due to the varying speed of the earth in its elliptical orbit and to the obliquity of the ecliptic. (*see* EQUATION OF TIME.)

Sun time changes for all places that have not the same longitude. New York time is a few minutes earlier than Boston time and later than Philadelphia time. It was used until the development of transportation made it necessary to simplify *timetables.* (*see* LOCAL TIME.)

Apparent time is the time as measured by the apparent motion of the true sun. It is equal to the hour angle of the true sun plus 12 hours, dropping 24 hours if the sum exceeds that amount.

Mean solar time or civil time is the average sun time. The days are of the same length throughout the year. It is the basis of all ordinary measurements of time. It is measured by the *mean sun* (an imaginary sun that moves uniformly eastward along the equator instead of on the ecliptic).

The day is considered to begin at midnight, and two periods of twelve hours each are reckoned.

Standard time. In 1884, an international conference at Washington established the plan of standard time. The surface of the earth was divided into 24 belts, each 15° of longtitude in width, and it was decided that the time in each belt should be the time at the meridian near its center. Therefore time changes by one hour at the boundary of each time belt. The dividing lines are not straight, nor are the widths of the belts all uniform.

There are four time belts crossing the United States and Canada. They are called Eastern, Central, Mountain and Pacific. Their times are the local times of the meridians 75°, 90°, 105° and 120° west of Greenwich. They are therefore, 5, 6, 7 and 8 hours slow by Greenwich time.

Universal time is, by agreement, the local time of the meridian of Greenwich near London, England.

time dilation

see FITZGERALD CONTRACTION. Also the idea that biological time slows down as an organism approaches the speed of light.

Titan

The largest of Saturn's satellites. It is a little smaller than Mercury and seems to have an atmosphere of ammonia and methane. (*see* SATELLITES OF THE SOLAR SYSTEM.)

Titan

An intercontinental ballistic missile of the U.S. Air Force, consisting of a two-stage, liquid-propellant rocket with 300,000 lbs. of thrust and a velocity of Mach 15, designed for a take-off weight of at least 100,000 lbs.

Titania

A satellite of Uranus. (*see* SATELLITES OF THE SOLAR SYSTEM.)

tolerance dose (of radiation)

see MAXIMUM PERMISSIBLE CONCENTRATION and MAXIMUM PERMISSIBLE LEVEL.

topographical latitude

A synonym for GEOGRAPHICAL LATITUDE (q.v.).

torrid zone

A belt around the earth 23½° either side of the equator, where the sun can be seen on the zenith at noon at some time during the year.

torsion balance

An instrument used in determining the mass of the earth. It consists of a light horizontal bar with a small ball at each end, supported at its center on a quartz fiber or very fine tungsten filament, the whole enclosed in a vessel from which the air has been exhausted.

It is a very delicate instrument and its use is very difficult.

total-annular eclipse

see ECLIPSE.

total eclipse

One in which the entire surface of the sun or moon is eclipsed. (*see* ECLIPSE.)

tower telescope

On Mt. Wilson, California, are two towers which are long telescopes. One is 60 feet, the other 150 feet tall. At the top is a dome housing a coelostat. The curved mirror is driven

at the rate of one revolution in 48 hours, thus keeping the reflected beam of light always falling on a second mirror set so as to throw the light down through a 12-inch lens. From the lens the light goes straight down, 150 feet, through the tower, to the observing room which is dug in the solid rock of the mountain beneath the tower. Here it forms an image of the sun 17 inches in diameter. The large size of the image is due to the great focal length of the lens.

Several other tower telescopes are in use at other observatories.

trace

Horizontal line normally appearing on the face of an oscilloscope.

track

In aerial navigation, the direction of travel of aircraft, etc. above the ground.

tracking

The process of keeping an instrument or a radio beam set on a target.

trail

(1) A long bright flash-like trace left in the sky by large meteors. (2) A line seen on a photographic plate which was not kept moving during a prolonged exposure

trajectory

The path traveled by a ballistic missile.

transducer

A device by means of which energy may flow from one or more transmission systems to one or more other transmission systems. The energy transmitted by these systems may be in any form (e.g., electric, mechanical or acoustical) and it may be of the same form or different forms in the various input and output systems. Thus, e.g., a telephone receiver

changes sound (variations in air pressure) into variations of an electrical current.

transfer ellipse

(ASTRONAUTICS) The course that an interplanetary rocket has to follow in order to move ("transfer") from an orbit around a celestial body into a different orbit around another; so called because it is a part of an ellipse. (*see* TANGENTIAL TRANSFER ELLIPSE.)

transistor

A small, light, compact electronic device for rectification or amplification, designed to replace a vacuum tube and to perform its functions without any appreciable generation of heat and with a minimum requirement of power.

transit

(1) The passage of a celestial body across the meridian. (Also called *culmination.*) The passage of the body across the upper branch of a meridian is its *upper transit,* and its passage across the lower branch of a meridian is its *lower transit.* (2) The passage of a smaller body across the disk of a larger one. (3) The term is also applied to the passage of the shadow of a satellite across the disk of its primary.

Mercury and Venus sometimes cross the face of the sun. (*see* MERCURY and VENUS.)

The satellites of Jupiter often cross the face of the planet, and so do their shadows, giving *shadow transits.*

transit circle, transit instrument

see MERIDIAN CIRCLE.

translunar space

That part of space conceived as a spherical layer centered on the earth, with its lower limits at the distance of the orbit of the moon, but extending to several hundred thousands of miles beyond.

transmutation

Changing one chemical element into another by atomic fission, or by the exchange of subatomic particles.

transsonic speed

Any speed between SUBSONIC and SUPERSONIC VELOCITIES (qq.v.); thus, in aeronautical engineering, any speed between $M = 0.8$ and $M = 1.3$ (where M is the Mach number).

transverse Mercator projection

Representation of part of the earth's surface by development of a cylinder tangent at any great circle other than the equator. (*see* INVERSE MERCATOR PROJECTION.)

triangulation

Computing a distance by measuring a base line and the angle of sight.

Used in measuring PARALLAX.

Triangulum [the Triangle]

A northern constellation.

Triangulum Australe [the Southern Triangle]

A southern constellation.

Triton

A satellite of Neptune. (*see* SATELLITES OF THE SOLAR SYSTEM.)

troilite

Native ferrous sulphide occuring in meteorites.

Trojan family of comets

see COMET.

Trojan group of asteroids

see ASTEROIDS.

tropic velocity

The greater flood or ebb velocity of tides when the moon is near its maximum declination. (*see* TIDES.)

tropical year

Period of one complete revolution of the earth around the sun relative to the vernal equinox. This is the year of the seasons, or the calendar year. Its length is 365.2422 mean solar days, or 365 days, 5 hours, 48 minutes, 46 seconds.

Tropics

The two parallels of celestial latitude which are the limits of the extreme north and south declination of the sun, i.e., where the sun turns at the solstices. The northern one is called the *Tropic of Cancer*, the southern one is the *Tropic of Capricorn*. They correspond to two parallels of latitude on the earth, situated on either side of the equator, each at a disance of 23° 27′ from it, which are the northern and southern boundaries of the *torrid zone* or "*the tropics*," in which the sun can be seen at the zenith at noon at some time of the year.

tropopause

The boundary of separation between the TROPOSPHERE and the STRATOSPHERE (q.v.) in the earth's atmosphere.

troposphere

The lowest layer of the atmosphere of the EARTH (q.v.), extending to an average height of 7 miles above the surface. Temperature decreases within it as the altitude increases. This is the atmospheric layer that contains most of the water vapor and clouds, dust and vertical air currents found in the atmosphere.

trough

Region between Earth and Moon where gravity of each is equal. (*see* ZERO GRAVITY.)

true anomaly

The angle between the radius vector and the line of apsides of an elliptic orbit, i.e., the angular distance of the revolving body from its point of the greatest or least distance from its

primary (i.e., in the case of a planetary orbit, from perihelion or aphelion).

true position (true place)

see CELESTIAL SPHERE.

true sun

The sun as it is actually seen to execute its apparent motion in the ecliptic owing to the earth's orbital motion. (*see* MEAN SUN, TIME.)

Tucana [the Toucan]

A southern constellation (south of Phoenix).

turbulence

An irregular, rapid motion, as observed in the atmosphere of the earth and the sun. (*see* SPECTRUM OF TURBULENCE.)

twilight

The period and the state of continued illumination of the atmosphere of the earth by the sun for a considerable time after sunset, and also before sunrise, i.e., while the sun is less than 18° below the horizon and some light is received by reflection of sunlight from dust and moisture particles in the upper atmosphere.

The *civil twilight* lasts about 30 minutes in the latitude of New York, or while the center of the sun is less than 6° below the horizon. It ends when the light is too dim for outdoor activities of the daytime, but is not dark enough to see the stars.

Nautical twilight ends when the center of the sun is 12° below the horizon.

Astronomical twilight lasts while the center of the sun is less than 18° below the horizon. Thus the faint stars can be seen only at the end of astronomical twilight.

Observational twilight begins or ends when the sun is 10° below the horizon.

Twilight is shortest at the equator, about 1 hour 10 min-

utes. It varies in temperate latitudes at different times of the year.

In the latitude of New York it is 1 hr. 30 m. at the equinoxes, and two hours in June.

Above latitude 48½° (Winnipeg or Vancouver, Canada) it lasts all night in late July. Above 66½° the midnight sun is seen. At the poles twilight lasts about six weeks. There is only one sunrise and one sunset a year.

Since twilight is an effect of the atmosphere, a twilight zone which we can see on Mars shows that it has an atmosphere. The absence of such a zone on the moon means that it has no atmosphere.

twilight glow

see AIRGLOW.

twinkling

A rapid changing of the apparent brightness of a star, its apparent position, and at times also of its color, produced by the irregular motions of the rays or beams of light arriving from the star; it has nothing to do with the properties of the star itself, but is merely an effect of turbulence in the atmosphere of the earth, owing to the presence of air currents of various temperatures, varying water vapor content, etc which change the densities of the atmospheric layers, resulting in refraction of the starlight and interference, producing the twinkling effect. On the other hand, the bright, naked-eye planets do not show this phenomenon, because owing to their larger angular diameters, the rays of light coming from them travel along slightly different paths, so that not all of them are deviated by the atmospheric layers simultaneously. The phenomenon is called also *scintillation.*—In radio astronomy, *twinkling* denotes a fluctuation often observed in the radiation emitted by radio stars. This fluctuation, since it displays a "periodicity" of the order of one minute, is currently considered likewise to be caused by refraction produced by irregularities in the atmosphere of the earth.

two-stage rocket

A STEP ROCKET (q.v.), consisting of two steps or stages.

Tycho's star

A very brilliant nova that appeared in Cassiopeia in 1572, and was observed and described by Tycho Brahe.

It is the brightest nova on record. It was visible to the naked eye from November 12, 1572 until the spring of 1574. (There were no telescopes at that time.) It became as bright as Venus, and was visible in full daylight.

Tychonic system

Tycho Brahe, unable to observe any parallax of the stars, refused to believe Copernicus' assumption of the earth's revolution.

He proposed a different system with a stationary earth. The sun and moon revolved about the earth, but all the other planets revolved about the sun.

His system was never widely accepted and did not last very long.

U

ultimate lines

The spectral lines which correspond to transitions of atoms to or from the lowest level of energy.

They are the characteristic lines that prove the existence of a certain chemical element in the sun or in any other star.

ultraviolet radiation

The invisible electromagnetic radiation beyond the violet end of the spectrum of visible light, of wavelengths ranging, roughly, from 4000 down to 400 angstroms.

umbra

The blackest part of a shadow from which all light is cut off.

In the shadow of the moon which causes an eclipse of the sun, it is the area where the eclipse is total. Surrounding it is a much larger area of penumbra, where the eclipse is partial.

In sunspots, it is the dark center of the spot that looks black. There is a lighter border of PENUMBRA (q.v.).

Umbriel

A satellite of Uranus. (*see* SATELLITES OF THE SOLAR SYSTEM.)

underluminous

Said of a star that radiates less light than a MAIN SEQUENCE (q.v.) star of its mass would be expected to be radiating according to the MASS-LUMINOSITY RELATION (q.v.).

U.S. artificial satellites

The first U.S. satellite was EXPLORER I, placed in orbit February 1, 1958. Next was Vanguard I, March 17, 1958, followed by Explorer III on March 26th. Explorer III had already fallen. EXPLORER I is expected to remain aloft until late 1962, and the lifetime of Vanguard I is of the order of 200 years.

universal laws of gravitation

see GRAVITATION.

universal laws of motion

see LAWS OF MOTION.

universal time

see [illegible]

universe

All of creation. Everything there is.

The word was formerly restricted to our galaxy or Milky Way, and so people spoke of other galaxies as "island universes." (*see* AGE OF THE UNIVERSE, EVOLUTIONARY THEORY OF THE UNIVERSE, EXPANDING UNIVERSE, STEADY-STATE THEORY OF THE UNIVERSE.)

upper air

That part of the atmosphere which embraces the IONOSPHERE and the EXOSPHERE.

upper branch of the celestial meridian

That half of the celestial meridian which lies between the poles and contains the zenith. (This half is usually referred to simply as *the meridian*, whereas the LOWER BRANCH [q.v.] is always specified as such.)

upper transit

Passage of a celestial body across the upper branch of the celestial meridian.

uranography

The study and mapping of the stars and their groups and clusters.

uranometry

The survey, study, measurement and mapping of the celestial sphere, and its regions, and the celestial bodies.

Uranus

The first planet ever "discovered." It was first seen, accidentally, in 1781 by William Herschel who was sweeping the sky with a 7-inch telescope of his own making. He saw an object larger than a star, which he first thought was a comet. Examination of records showed that it had been observed twenty times before and had been recorded as a star. From these records an orbit was computed which proved it to be a planet.

Distance from the sun 1782 million miles, 19.2 times the distance of the earth.

Diameter 32,000 miles, 4 times that of the earth.

Period of revolution 84 years.

Period of rotation 10 hours 45 minutes.

Mass 14.7 times that of the earth.

Density 1.27 times that of water.

Uranus is just visible to the naked eye under the best seeing conditions. With a telescope it appears as a small, blue-green disk.

Very faint cloud belts have been seen.

The planet has an atmosphere of methane with only a trace of ammonia vapor.

It is the great absorption of red and yellow light by the methane that makes the planet look green.

Due to its distance, sunlight on Uranus is so weak that its surface temperature is less than —300°F.

Uranus has 5 satellites, varying from about 400 to 1000 miles in diameter, which revolve rapidly in the plane of the

equator. This plane is inclined 97.8° to the plane of the ecliptic, which is very different from any other planet.

Ursa Major [the Great Bear]

A large, northern constellation, of which the most conspicuous part is the Big Dipper.

It is one of the best known of all the constellations and one of the oldest. It is mentioned in the Book of Job.

Peoples in many countries have called this group of stars a bear. The handle of the dipper forms the bear's tail. Its head is a triangle of faint stars, and its feet are marked by three pairs of little stars almost in a straight line, under the bowl of the dipper.

Ursa Major Cluster

A widely scattered group of about 126 stars, including five of the stars of the Big Dipper. Some of the others are Sirius, Gemma in the northern Crown and Beta in Auriga.

They are widely scattered in the sky because our sun is now passing through the cluster, but is not a part of it.

These stars occupy a spherical space about 450 light-years in diameter. They are all moving toward a point in the Milky Way south of Capricornus, at the rate of 18 miles per second.

Ursa Minor [the Little Bear]

The most northerly of all the constellations since Polaris, the North Star, is at the tip of the tail of the Little Bear, or the end of the handle of the Little Dipper.

It is a small constellation consisting essentially of only the seven stars of the Little Dipper.

The two stars at the end of the bowl of the dipper, Kochab and Pherkad, are called the "guardians of the pole."

V

vacuum

Theoretically, a space devoid of all matter. Practically, and experimentally, a region in which atmospheric pressure has been reduced to as low a value as possible.

vacuum bolometer

An instrument used to record the intensity of sunlight at every wavelength.

It relies on the changes in electrical resistance of a fine, blackened wire, as it rises in temperature because of radiation falling upon it.

Vanguard

The three-stage rocket developed as the launching vehicle of U.S. ARTIFICIAL SATELLITES. It is a finless rocket, shaped like a giant rifle cartridge, 72 feet in length, with a maximum body diameter of 45 inches and its total weight is over 22,000 lbs. The first-stage motor burns a liquid propellant, delivers close to 30,000 lbs. of thrust and develops a velocity of about 4000 m.p.h. by the time it reaches burnout at an altitude of about 36 miles. The second stage, likewise using a liquid propellant, builds the velocity up to about 11,000 m.p.h. and its burnout comes at an altitude of 130 miles, from which the vehicle coasts up to the 300-mile level where the second stage separates from the third. The third-stage rocket utilizes a slow-burning solid propellant and accelerates to the velocity of 18,000 m.p.h. required for a closed orbit.

variable nebula

A NEBULA (q.v.) that varies in shape and brightness. Two of the best known variable nebulae are in the constellations Corona Australis and Monoceros.

variable star

A star the brightness of which changes from time to time owing to causes that operate outside the atmosphere of the earth. The more than 20,000 variable stars known today can be classified variously. The most commonly used classifications are: (1) CEPHEID VARIABLES, (2) CLUSTER-TYPE (or RR LYRAE) VARIABLES, (3) LONG-PERIOD VARIABLES, (4) NOVAE, and (5) ECLIPSING VARIABLES (qq.v.). Those grouped into the first four classes are known collectively as *intrinsic variables*, since their light output varies because of internal causes; the eclipsing variables are *extrinsic variables* because their light output is stable, and the variations are due to their periodic obscuration by a companion star. Another well known classification is that of Gaposchkin and Gaposchkin, according to which the variable stars are divided into: (1) ECLIPSING VARIABLES, and (2) the GREAT SEQUENCE, the latter subdivided into (a) CLUSTER-TYPE VARIABLES, (b) CEPHEID VARIABLES, (c) RV TAURI STARS, (d) SEMIREGULAR VARIABLES, and (e) LONG-PERIOD VARIABLES (qq.v.). The average interval required by a variable star to complete a full cycle of variations is known as its *period*. (*see also* IRREGULAR VARIABLES NOMENCLATURE OF STARS, SECULAR VARIABLE.)

variation

Error in a magnetic compass owing to the fact that the north magnetic pole of the earth is not coincident with the true, geographic north pole. This error equals, at any given place, the angle formed by the MAGNETIC MERIDIAN and the TRUE MERIDIAN (qq.v.), i.e., the angle between the direction of the magnetic north as indicated by the compass and the direction of the true north. It is named *east* and marked plus

(+) if the magnetic north is eastward of true north, otherwise it is said to be west and marked minus (—).

variation of latitude

see WANDERING OF THE EARTH'S POLES.

Vega

The traditional name of the star α Lyrae (*see* STARS—*Plate X.*)

Vega is the 5th brightest star in the sky. It is 100 times as bright as the sun, and is 26 light years away. It crosses the meridian almost exactly at the zenith at 9 P.M. on Aug. 12. It is a double star with a 10th magnitude companion.

Vega will be the pole star 12,000 years from now.

Vela [the Sail]

A part of the old constellation ARGO (q.v.) now regarded by astronomers as a separate constellation.

velocity

Rate of motion, change of position or displacement in a given direction, expressed in units of linear measurement per unit time (with reference to the motion of celestial bodies, usually in miles or kilometers per second).

velocity-distance relation

According to recent observations, all the exterior galaxies, except the very nearest ones, are moving away from us with velocities that increase rapidly with the increasing distance of the galaxy. For the most distant ones the velocities are tens of thousands of miles per second.

The velocity varies directly as the distance at the rate of 350 miles per second for each three million light-years of their distance from the earth. Recent research, however, indicates that this value may be considerably too large.

velocity of escape

The speed that any object must acquire in order to escape from a planet's gravitation.

If the planet's mass, M, and radius, r, are known, the square of the velocity of escape is:

$$U^2 = 2G\left(\frac{M-m}{r}\right),$$

where m is the mass of the escaping particle (usually so small that it is ignored), and G is the constant of gravitation, 6.67×10^{-8}.

This applies to the ability of a planet to retain an atmosphere. If the molecules of gas are moving faster than the velocity of escape they will leave the planet for outer space.

The velocity of escape at the earth's surface is 7 miles a second. On the moon it is only 1½ miles. These are the velocities that a rocket must attain in order to leave the earth or the moon and travel in interplanetary space. (In rocketry, the term *escape velocity* is preferred to "velocity of escape.") The velocities calculated in miles per second for the other planets of the solar system are: Mercury, 2.2; Venus, 6.3; Mars, 3.1, Jupiter, 37.0; Saturn, 23.9, Uranus, 13.0; Neptune, 14.0, for Pluto, it cannot be determined since we have no definite knowledge concerning the mass and diameter of that planet.

velocity of light

Roemer, a Danish astronomer, first demonstrated that light moved at a finite speed in 1675, by timing the eclipses of Jupiter's moons.

It has been measured very accurately, several times since then, and the accepted figure now is 186,270 miles or 229,774 kilometers per second.

This is the velocity of light in a vacuum.

Venus

The brightest object in the sky, except the sun and the moon.

Second planet out from the sun. Mean distance 67 ?90,000 miles.

Nearly the same size as the Earth. Diameters: Venus 7,700; Earth 7,927 miles.

Period of revolution 224.7 days.

Period of rotation unknown, probably about 30 days.

Mass .81 that of the earth.

Density 4.86 that of water. The earth's is 5.52.

Venus, when brightest, can be easily seen in the daytime, and at night it casts shadows.

The Greeks called it Phosphorus when it was a morning star and Hesperus when an evening star.

It is the nearest planet to the Earth, its distance varying from 26 to 160 million miles.

Venus, like Mercury, shows phases as the moon does, because its orbit is within the orbit of the Earth.

Because of the very great difference in distance, the apparent diameter changes over 6 times between the crescent and full phases.

Its orbit is more nearly a circle than that of any other planet. It is inclined to the ecliptic at an angle of 3° 24′.

Its albedo is .59, which is eight times that of the moon and eight times that of Mercury.

This very high reflecting power indicates that the surface is covered with clouds, but they are probably not clouds of water.

No permanent markings have been seen, which is the reason for not knowing the time of rotation.

Venus has an atmosphere comparable in depth to that of the earth. But we can find no oxygen and no water vapor in it.

It contains in it about 10,000 times as much carbon dioxide (CO_2) as does the atmosphere of the earth.

Because it is much nearer the sun, it is probably much hotter than the earth. Measurements of daytime temperatures have been recorded as high as 140° F. and of night temperatures as low as —9°F.

It has been suggested that the clouds consist of formaldehyde instead of water, and that below them may be oceans of plastics. But this has not been proved.

vernal equinox

The position on the celestial sphere occupied by the sun on or about March 21 when its path on the ecliptic crosses the celestial equator going from south to north. This point is also called the March equinox and the First Point of Aries.

vernier

A short auxiliary scale made to slide along the divisions of a graduated instrument, to indicate fractions of the divisions of the larger scale.

One is commonly used on the arc of a sextant and on a barometer and on other precise measuring instruments.

Veronique

A French liquid-propellant rocket used in high-altitude research; it has an overall length of 24 feet, a body diameter of over 21 inches, a take-off weight of 771 lbs. and can carry a maximum payload of 132 lbs. It is capable of reaching a maximum altitude of 84 miles.

vertex

The highest point reached by a celestial body. That point on a GREAT CIRCLE (q.v.) nearest a pole. (*see* also STAR DRIFT.)

vertical circle

A circle on the celestial sphere, drawn through the zenith and perpendicular to the horizon. Analogous to a meridian of the earth.

The altitude of a celestial body is measured upward from the horizon along such a circle.

Vesta

The third largest of the ASTEROIDS (q.v.).

Viking

The designation of a series of rockets produced and employed for high-altitude research.

Virgo [the Virgin]

The sixth constellation in the zodiac.

A large group, with one 1st, and eight 3rd magnitude stars, forming an irregular Y between Leo and Libra.

It represents Ceres, the goddess of the harvest, with a few heads of wheat in her hand. The sun is among these stars in August, the time of harvest.

The very bright star, Spica, forms the heads of wheat. It is much brighter than the sun, and is 160 light-years away. It is a spectroscopic binary, a bright star with a dark companion of enormous mass, which revolves in the very short period of four days.

Gamma Virginis, at the branching of the Y, is a very fine double for viewing with small telescopes.

Virgo Cluster of Galaxies

The nearest, brightest and apparently the largest of the great clusters of external galaxies.

In the constellation Virgo, within an area about 15° square (twice as large as the bowl of the Big Dipper), photographs show 2775 galaxies. The brightest of these, several hundred in all, belong to the Virgo cluster, which is at a distance of about 16 million light-years from the earth.

visible horizon

The line at which the earth and sky appear to meet.

visual binaries, visual doubles

BINARY STARS (q.v.) that appear as single stars to the naked eye, but are separated into pairs by the telescope.

visual magnitude

The magnitude of a celestial body to the human eye. (*see* MAGNITUDE.)

Volans [the Flying Fish]

A southern constellation, often referred to as *Piscis Volans.*

volvelle

An elaborate medieval instrument designed to show the phases of the moon as well as its position in the sky relative to the sun and the earth, and to aid in the solution of various astronomical problems.

vortex

Whirling motion as in a whirlpool or a whirlwind.

Sunspots are supposed to be caused by such motion in the gases of the sun.

Vulcan

The name of a hypothetical INTRA-MERCURIAL PLANET (q.v.) the existence of which is generally denied by present-day astronomers.

vulgar establishment

At any point, the interval after the meridian transit of the full or new moon until the next high tide. Since such transits occur near midnight or noon, the vulgar establishment indicates the approximate time of the following high tide on those dates. (*see* TIDES.)

Vulpecula [the Fox]

A constellation between Aquila and Cygnus.

W

W Ursa Majoris-type variables

see ECLIPSING VARIABLES.

WAC Corporal

The high-altitude research rocket that was eventually developed into the AEROBEE (q.v.).

wandering of the earth's poles

It is known that the latitude of any place on earth is continually changing.

The north and south poles wander about very irregularly over small areas not so large as a baseball diamond. There seems to be two motions. One is an ellipse 30 feet long in a period of 12 months; the other a circular motion slightly smaller in a period of 14 months.

Neither pole moves more than 40 feet from its average position.

The cause is a shifting of the earth on its axis. It must not be confused with PRECESSION (q.v.).

waning moon

The moon between the PHASES (q.v.) known as "full" and "new," when its light appears to be diminishing, because a smaller visible area is illuminated.

war time

see DAYLIGHT SAVING TIME.

warhead

(ROCKETRY) An explosive charge carried by a rocket or missile, usually in the nose compartment.

water clock

Probably invented in Egypt many centuries ago. It was a vessel shaped like an inverted cone, with a small hole at the bottom, and graduations on the inside to mark the hours.

Filled with water which ran out slowly, the level of the water would indicate the time.

Another form was used where water flowed into one graduated vessel, from another at a fixed elevation to keep the pressure constant.

Water clocks were introduced into Greece before 135 B.C. They were used in many countries and for many centuries. Also called a clepsydra, or "thief of water."

They gave rise to the sand-glasses.

watt

A unit of measure of electrical power for electric light bulbs or other electrical devices in terms of the current they consume.

Mazda lamps give approximately 1 candle power of light per watt.

wave number

With reference to an electromagnetic radiation (e.g., light), the reciprocal of the WAVELENGTH (q.v.), i.e., the number of waves in a length of 1 centimeter along the line of advance of the wave motion.

wave theory of light

The currently generally accepted theory that light is a wave phenomenon, and not any stream of material particles, as held by the formerly accepted CORPUSCULAR THEORY (q.v.), although the concept of the photon may be regarded as a return, to some extent at least, to that theory. According to the wave theory, light is produced by waves spreading outward in all directions from a source of light, much as water waves

spread over the surface of a pond when a stone is thrown into it, and the waves of different wavelength (i.e., different lengths from crest to crest) produce the different colors of the spectrum; all waves have the same speed of propagation in vacuum, but move more slowly through air, water or transparent substances, the retardation being greater for the shorter waves than for the longer ones.

wavelength

The distance traveled by a periodic disturbance (light, etc.) in one period or cycle, i.e., the distance between two successive peaks or wave crests.

waxing moon

The moon between the PHASES (q.v.) known as "new" and "full," when its light appears to be increasing, because a larger area is visible.

web

(ASTRONAUTICS) The wall thickness of a GRAIN (q.v.).

week

The seven-day week seems to have come from the Babylonians. Among them the 7th, 14th, 21st and 28th days of each month were termed "days of rest" and on them certain works were forbidden to be done.

The Jews evidently borrowed it from Babylon. The week was not used by the ancient Romans. It was introduced by the Christian emperors.

The seven days were named for the seven moving bodies in the sky, the sun, moon and the five naked-eye planets.

The names of the days come from the gods for whom the planets were named.

It is easy to see that Sunday is Sun's day, Monday is Moon's day, and Saturday is Saturn's day. The other four names come from the Norse gods. They called Mars, Tieu; Mercury, Wodin; Jupiter, Thor; and Venus, Fria. From these we get Tuesday, Wednesday, Thursday and Friday.

weight

The action of the force of gravity on a body; it is the product of the mass of the body and the acceleration of gravity. Since the acceleration of gravity decreases with the distance from the center of the earth, the same body weighs less on a mountain than at sea level. Furthermore, the weight of one and the same body would be different on the different planets or stars (the greater the mass of the celestial body on which it would be weighed, the more its weight would be), even though its mass would be naturally unchanged.

weightlessness

(ASTRONAUTICS) *see* ZERO GRAVITY.

white dwarf stars

A small class of small, very dense white stars of low luminosity.

They are often no larger than the earth, although they weigh as much as the sun. The companion of Sirius is a good example.

One in Eridanus has a volume of only six millionths that of the sun, but its mass is 45% of the sun's, which gives it a density 100,000 times that of water, or nearly two tons per cubic inch.

Van Manaen's Star is 3 ten-millionths the sun's volume and has a density of nearly 7 tons per cubic inch.

Widmanstaetten figures

Very characteristic figures of the crystals of iron in meteorites.

To show them, the meteorite is sawed, polished and then etched with acid.

No iron from mines on earth shows such crystal structure.

Wien's law

The wavelength for which a radiation is the most intense, is inversely proportional to the absolute temperature.

$$\lambda_n = 0.289/T$$

winter solstice

The position on the ecliptic occupied by the sun about December 22 when it reaches its greatest southerly declination.

Wolf-Rayet stars

A stellar classification, comprising less than 100 distant stars with class *W* and *O* spectra (bright bands superimposed on a faint continuous spectrum), all of which are very bright, and the hottest of all known stars, with temperatures ranging from 35,000 to 100,000° C

work

The effect of the movement of the point of application of a force along the line of action of the same force, it equals the force times the distance through which it acts

world calendar

see CALENDAR.

world line

In the THEORY OF RELATIVITY, a curve representing the motion of an object in the SPACE-TIME CONTINUUM (q v)

X

x-rays

Very short wavelength radiations beyond the ultra-violet in the spectrum.

They are about one ten-thousandth as long as the visible violet, and are very penetrating.

X-17

A three-stage rocket, about 48 feet in overall height, designed and employed as a research missile to study RE-ENTRY (q.v.) problems.

Y

Yagi aerial

A type of directional aerial used in radio astronomy, in which only one dipole is connected to the FEEDER that leads to the RECEIVER (q.v.), and the other dipoles are "parasitic" (without direct connection to the receiver terminals).

year

A year is the period of the earth's revolution around the sun, or of the sun's apparent motion along the ecliptic with reference to different datum points.

Sidereal year. The interval of time in which the sun apparently performs a complete revolution with reference to the stars. It is the true period of the earth's revolution. Its length is 365 d. 6 hr. 9 m. 9.5 s. or 365.25636 days. It is increasing at the rate of .01 second a century.

Tropical year. The interval between two successive returns of the sun to the vernal equinox. It is the year of the seasons Its length is 365 d. 5 h. 48 m. 46 s. or 365.24220 days. It is diminishing at the rate of .53 second a century. It is about 20 minutes shorter than the sidereal year due to the precession of the equinox.

Calendar year. The year as measured by the Gregorian calendar. Its length is 365 d. 5h. 49 m. 12 s. of mean solar time, which is only 26 seconds longer than the true, or sidereal year.

Anomalistic year. The interval between one perihelion and the next. It is a little longer than the sidereal year, because

the line of apsides of the earth's orbit moves slowly eastward. Its length is 365 days 6 hrs. 13 min. 53.0 sec.

Cosmic year is the period of rotation of our galaxy, about 220 million years.

ylem

The hypothetical primordial matter, proposed by George Gamow, from which the chemical elements may have been formed.

Z

Zeeman effect

Zeeman, a physicist, in 1896, discovered that the lines in the spectrum are split into two or three, when the source of light is in a strong magnetic field.

In the spectra of spots near the center of the sun the lines are double, for spots near the limb they are triple.

This shows that there are strong magnetic fields around sunspots, evidently produced by the whirling of the gases in the spot.

zenith

The point of the celestial sphere directly overhead, 90° above the horizon, for any point on earth; it is the point where a plumb line extended upward would intersect the celestial sphere.

zenith distance

The angular distance of a celestial body from the zenith, measured downward along a vertical circle i.e., one perpendicular to the horizon, for bodies above the horizon. It is therefore the complement of the altitude of the celestial body, i.e., 90° minus the altitude.

zero gravity

(ASTRONAUTICS) The state that prevails at the point or region where the pull of gravity is cancelled out by the centrifugal force, resulting in a sensation of "weightlessness."

zodiac

A band of the celestial sphere, 16° wide, 8° on either side of the ecliptic. It is divided into 12 equal sections, each 30° wide called the *signs of the zodiac.* The signs are named for the constellations that were located in them in the time of Hipparchus, over 2000 years ago. They are named eastward from the vernal equinox. The sun passes through three signs during each season of the year, as follows: Spring—Aries, Taurus, Gemini; Summer—Cancer, Leo, Virgo; Autumn—Libra, Scorpius, Sagittarius; Winter—Capricornus, Aquarius, Pisces.

Due to the precession of the equinoxes, the signs and the constellations do not correspond now, as they did when the signs were named. On the 21st of March, when spring begins, the sun enters the sign of Aries, but it is in the constellation Pisces. The sun does not enter the constellation Aries until the latter part of April.

It is the "circle of animals" because all but one of the constellations represent real or imaginary animals. The one exception is Libra, the Balance.

Hipparchus knew only 11 constellations in the zodiac. Scorpius was stretched out over two spaces, and was sometimes represented by two scorpions. Ptolemy speaks of the Claws and the Scorpion. No one seems to know just when the claws were changed into the Balance, but the constellation Libra appears to have come from the Chaldeans. Possibly it was named because that was where the autumnal equinox was in some ancient epoch, and the days and nights balanced or were equal.

zodiacal constellations

see Plate XII.

zodiacal light

A faint glow, sometimes as bright as the Milky Way, seen in the evening, a little after sunset, in March, or in the morning, before sunrise, in September. It is seen on nearly every clear night in the tropics as a wedge of light, widest at the

horizon and sometimes reaching to the zenith. On very rare occasions it has been seen to extend all the way round the sky along the ecliptic.

It is, apparently, the reflection of sunlight from a swarm of meteoric particles that surrounds the sun and extends out beyond the orbit of the earth.

A bright spot, but still very faint, in it that is just opposite the sun, is called the *gegenschein*.

Zone

A belt or girdle. The surface of the earth is divided into five zones, limited by observed positions of the sun.

Torrid zone, 23½° each side of the equator. Here the sun is in the zenith at noon at some time during the year.

Temperate zones. From 23½° to 66½° either north or south latitude. Here the sun is either south or north of the zenith, but rises and sets every day in the year.

Frigid zones. From 66½° to 90° either north or south latitude. The sun is circumpolar here, above the horizon for 24 hours for a part of the year. At the poles there are 6 months of day and six months when the sun does not rise.

zone of avoidance

An irregular zone in our galactic system, extending along the Milky Way, in which no extragalactic nebulae are observed.

zone time

Local mean time of the nearest meridian representing a degree of longitude exactly divisible by 15.

ACKNOWLEDGMENTS

The editors take great pleasure in expressing grateful acknowledgment and sincere thanks to the following publishers for their kind permission to quote copyrighted material from the following books:

The American Society of Mechanical Engineers, New York, N. Y., publisher of *Terms in Nuclear Science and Technology* (ASA N1.1-1957).

The Clarendon Press, Oxford, England, publisher of *Radio Astronomy* by J. L. Pawsey and R. N. Bracewell.

Chapman & Hall Ltd., London W.C. 2, England, publisher of *Radio Astronomy* by A. C. B. Lovell and J. A. Clegg.

Harper & Brothers, New York, N. Y., publisher of *Astronomy* by J. C. Duncan.

Harvard University Press, Cambridge, Mass., publisher of *Galaxies* by H. Shapley and *Stars in the Making* by C. Payne-Gaposchkin.

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G. P. Putnam's Sons, New York, N. Y., publisher of *Field Book of the Skies* by W. T. Olcott, revised by R. N. Mayall and M. W. Mayall.

Random House, Inc., New York, N. Y., publisher of *The Changing Universe* by J. Pfeiffer.

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The Viking Press, Inc., New York, N. Y., publisher of *Introducing the Constellations* by R. H. Baker; *Radiation* by J. Schubert and R. E. Lapp; *Across the Space Frontier* by C. Ryan (ed.); *The Birth and Death of the Sun* by G. Gamow; *The Creation of the Universe* by G. Gamow.

Yale University Press, New York, N. Y., publisher of *The Inner Metagalaxy* by H. Shapley.

United States Air Force, Maxwell Air Force Base, Ala., publisher of *Interim Glossary, Aero-Space Terms.* (Definitions due to Dr. Woodford A. Heflin.)

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